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MULTIPLE SCATTERING TREATMENT FOR USE IN THE LOWTRAN AND FASCODE MODELS

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An evaluation of available approaches to treat the coupled processes of multiple-scattering due to atmospheric molecules and aerosols, and nongray absorption due to atmospheric gases is performed. Based on the evaluation and consideration of the requirements of efficiency, accuracy and code structure of LOWTRAN and FASCODE models, we recommend that an approach based on the stream approximation together with the k-distribution method is best suited for implementation into these models. The parameterization is unique in the (over)

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sense that the k-distribution method decouples the multiple-scattering from the treatment of non-gray gaseous absorption so that the stream approximation can be used to treat multiple scattering in both the LOWTRAN and FASCODE models. The stream approximation is extremely attractive since it retains the analytical simplicity (and hence, efficiency) of single scattering while improving the treatment of multiple-scattering (and hence, accuracy). Therefore, the parameterization is a uniform approach for solar, thermal and microwave regimes and can provide a general methodology to treat multiple-scattering due to aerosols, clouds and precipitation in the presence of gaseous absorption within the LOWTRAN/FASCODE formalism.

Calculations are performed to compare the accuracy of the stream approximation to numerical multiple scattering treatments for solar, thermal, and microwave spectral regions. Results indicate the approach can achieve RMS accuracies of about 20 percent in radiance for domains of optical properties characteristic of realistic atmospheric models.

The multiple scattering parameterization is implemented in both FASCODE and LOWTRAN models. FASCODE and LOWTRAN multiple scattering radiance results are compared to exact treatments. These results indicate that the new multiple scattering versions of these models provide more accurate simulations of the path dependent radiance than do their nonscattering counterparts. To insure consistency, multiple scattering versions of LOWTRAN and FASCODE are compared to one another.

Finally, recommendations are presented to further exploit the capabilities introduced here.

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1. INTRODUCTION

1.1 Background

Optimal design and deployment of electro-optical (EO) remote sensing and communication systems requires accurate modeling and prediction of the effects of the ambient environment on atmospheric transmission. Atmospheric transmittance/radiance models such as AFGL's LOWTRAN (Kneizys et al., 1983) and FASCODE (Clough et al., 1986) have been developed within this context to provide the capability to assess potential adverse environmental impacts on EO system performance.

In order to accurately predict atmospheric effects on the propagation of visible, infrared and microwave radiation, it is necessary to treat the extinction mechanisms including molecular scattering and absorption, and particle (aerosols, clouds and precipitation) scattering and absorption, characterizing the ambient atmosphere. In the present AFGL transmittance/radiance models, these processes are adequately included in the treatment of path transmission. However, simplified treatments are employed to simulate the effects of scattering on the calculation of radiance. For thermal infrared and microwave radiation, for example, particle scattering in LOWTRAN has been treated as an enhancement to extinction but not as a source term. This approach leads to an underestimate of radiance for paths where multiple scattering is important (Ben-Shalom et al., 1980). LOWTRAN uses the single scattering approximation for evaluating solar radiances (Ridgway et al., 1982). While the single scattering implementation is straightforward, its application introduces errors which are functions of wavelength, sun/sensor geometry, and surface optical properties (cf. Isaacs and Özkaynak, 1980; Dave, 1981). These errors are primarily due to neglecting higher order scattering and surface reflection. In FASCODE, particle scattering has been treated as equivalent to absorption. All scattered radiation is thus re-emitted as if it were absorbed, i.e., the scattered radiation is conserved. This conservative scattering approach can lead to an overestimate of radiance.

In order to provide a more realistic simulation of radiation in spectral regions and along atmospheric paths where multiple scattering (MS) is a significant contribution to the source function, an efficient and accurate scattering parameterization has been incorporated into the LOWTRAN and FASCODE models.

1.2 Objective of the Present Study

A two-year research program supported by AFGL/OPI was undertaken at Atmospheric and Environmental Research, Inc. (AER). The overall program objective was to incorporate a uniform, compatible, accurate and efficient multiple scattering scheme into the present LOWTRAN/FASCODE models so that the multiple scattering effects due to particulates could be realistically treated. The first phase of the program was to study and evaluate the available multiple-scattering parameterizations and recommend the most appropriate one for its incorporation into the transmittance/radiance models. Constraints of efficiency, accuracy, and code structure of LOWTRAN/FASCODE were the key considerations of the evaluation processes. The results of a trade-off analysis to determine an appropriate approach are summarized in Appendix A. The second phase of the study was to implement the most suitable multiple scattering parameterization into the LOWTRAN and FASCODE models, test the resulting multiple scattering versions and document the codes.

This report summarizes the work accomplished in the second phase of the overall effort. Following this introduction, the selected approach for multiple scattering is described in detail (Section 2). In Section 3, the implementation of the multiple scattering parameterization within the LOWTRAN/FASCODE models is discussed in detail. Comparisons of the implemented code are made to exact treatments and to one another in Section 4. Finally, recommendations are provided in Section 5 for enhancing the multiple scattering capability provided here.

2. MULTIPLE SCATTERING APPROACH

2.1 Stream Approximation

Selection of an appropriate treatment of multiple scattering (MS) for application to the LOWTRAN and FASCODE models is severely constrained by competing requirements of desired efficiency and accuracy, and limitations imposed by the inherent code structures of these models. Additionally, it is desired to provide an approach which is uniformly applicable to all spectral regions considered and equally appropriate for implementation within both LOWTRAN and FASCODE. Based on these considerations, the MS parameterization selected consisted of a finite stream approach (using two streams for simplicity) to approximate the scattering source function.

This approach could be implemented directly in FASCODE since it is essentially a monochromatic calculation. It is known, however, that there exist difficulties in calculating the transmittance/radiance averaged over a finite spectral interval in a nongray gaseous absorber with multiple scattering because the commonly-used band models are not applicable (cf. Stephens, 1984). Such is the case for implementing an MS treatment within LOWTRAN. The best approach to solve this problem is the use of the k-distribution method, which decouples the multiple scattering from the gaseous spectral integration so that the available (monochromatic) multiple scattering algorithms can be used directly. For LOWTRAN, the stream approximation is performed through an interface routine consisting of the k-distribution method. For practical purposes, this consists of decomposing the band model determined optical properties into a set of equivalent monochromatic calculations which are then summed to give the spectrally averaged results. The configuration of the multiple scattering approach for LOWTRAN and FASCODE is summarized in Figure 2-1.

As mentioned earlier, the multiple scattering parameterization has to be accommodated by the present LOWTRAN and FASCODE code structures. This constraint is particularly important for FASCODE. In the FASCODE application, gaseous absorption is evaluated directly from the line-by-line calculation. Fluxes required for the stream approximation are calculated via the parameterized adding method. The adding method is particularly consistent with the code structure of both radiance/transmittance models since they treat one layer at a time.

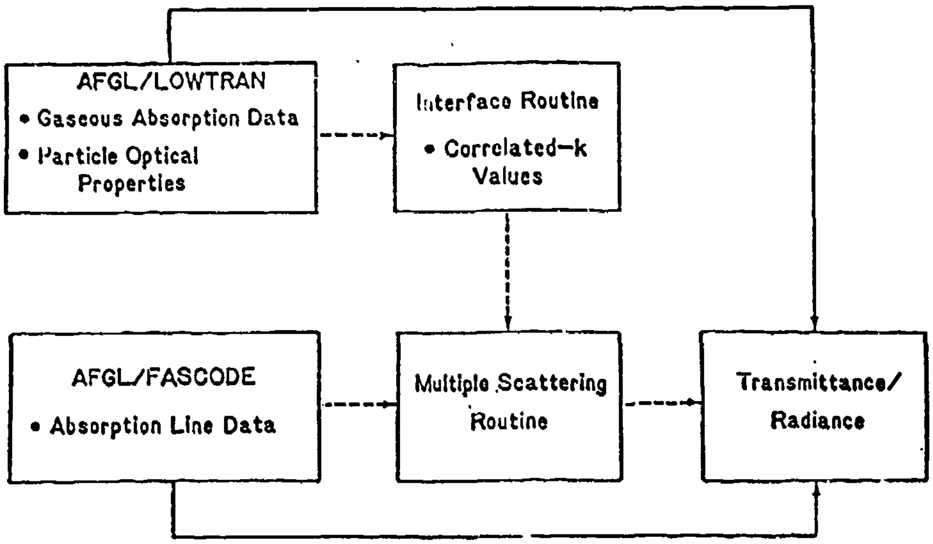


Fig. 2-1. AFGL transmittance/radiance code structure -- present models (solid line) with MS parameterization (dashed line).

In the FASCODE model, for example, the evaluation of layer optical properties always commences with that level in the selected path with the highest pressure and the selected spectral sampling interval decreases with pressure. This approach insures that the layer spectral resolution is consistent with the decrease of Voight line widths at higher altitudes. From the perspective of the line-by-line calculation, this method is computationally quite efficient. However, it is inconsistent with monochromatic multiple scattering treatments. In order to accomodate the sampling requirements of both the line-by-line and multiple scattering calculations, the FASCODE implementation employs the adding formalism to aid in the merging of the scattered fluxes from successive layers.

2.2 Theory

We provide a generic outline of the basic theory here. This prescription is modified slightly for specific application to the LOWTRAN and FASCODE models. Details of the specific model implementations are described in Section 3.

2.2.1 Radiance and Source Function

The desired radiance I_ν at wavenumber ν for an arbitrary path with zenith angle cosine and azimuth angle (μ,ϕ) is given by the solution to the radiative transfer equation (RTE):

$$\mu \frac{d}{d\tau} L_\nu(\tau,\mu,\phi) = L_\nu(\tau,\mu,\phi) - J_\nu(\tau,\mu,\phi). \tag{2.1}$$

Here τ_ν is the optical thickness, μ is then cosine of the path zenith angle, and ϕ is the azimuth angle relative to the sun's azimuth. Vertical optical depth, τ_ν, will depend on the relevant mechanisms determining the extinction of electromagnetic radiation for the spectral region characterized by wavenumber, ν. In general these mechanisms include: (a) molecular absorption, k_a, (b) molecular scattering, k_s, (c) particulate absorption, σ_a. and (d) particulate scattering, σ_s. Optical depth is given by integrating the relevant vertical extinction coefficient profiles according to:

$$\tau_\nu(z) = \int_z^\infty [k_a(z) + k_s(z) + \sigma_a(z) + \sigma_s(z)]\, dz$$

The general source function, J_ν, including scattering of solar radiation and thermal emission, is given by:

$$J(\tau,\mu,\phi) = J_o(\tau,\mu,\phi) + J_{MS}(\tau,\mu,\phi) \tag{2.2}$$

where

$$J_o(\tau,\mu,\phi) = \frac{\omega_o(\tau)}{4\pi} \pi F e^{-\tau/\mu_o} P(\Omega;-\Omega_o) + \left[1-\omega_o(\tau)\right] B[\theta(\tau)] \tag{2.3}$$

and

$$J_{MS}(\tau,\mu,\phi) = \frac{\omega_o(\tau)}{4\pi} \int_\Omega P(\Omega;\Omega') I(\tau,\Omega')d\Omega'. \tag{2.4}$$

Here, ω_o is the single scattering albedo, P is the appropriate angular scattering or phase function, and B is the Planck function at temperature θ. The extraterrestrial solar irradiance is given by F and the path and solar directions are given by Ω and Ω_o, respectively. The first term in Equation (2.3) is the single scattering of solar radiation while the second is the local thermal emission.

Radiance solutions to the RTE (Eq. (2.1)) are subject to boundary conditions at the top of the atmosphere ($\tau = 0.0$) for downward radiance and at the earth's surface ($\tau = \tau^*$) for upward radiance. At $\tau = 0.0$, downward diffuse radiance from space is zero (the direct solar irradiance is accounted for via the primary source function) resulting in:

$$I_b(0,-\mu,\phi) = 0.0 \tag{2.5}$$

(At millimeter wave frequencies a contribution due to emission at the cosmic background effective temperature of 2.7 K may be included when high accuracy is required.)

Boundary conditions at the surface will depend on the nature of the surface reflectance/emittance properties. The most common assumption is that of Lambert reflectance, i.e. the upward isotropic flux given by a constant surface albedo, r, times the downward flux. Upward and downward fluxes $F^{\pm}(\tau)$ at optical depth τ, are defined respectively as:

$$F^{\pm}(\tau) = \int_{o}^{2\pi} \int_{0}^{1} I(\tau,\pm\mu,\phi)\mu d\mu d\phi \tag{2.6}$$

This results in a lower boundary condition upward radiance of:

$$I_b(\tau^*,\mu,\phi) = \frac{r}{\pi}\left[\pi F\mu_o \exp(-\tau^*/\mu_o) + \int_{o}^{2\pi} \int_{o}^{1} I(\tau^*,-\mu,\phi)\mu d\mu d\phi\right] + (1-r)\, B[T_s] \tag{2.7}$$

The three terms on the R.H.S. of (2.7) are respectively: (a) reflectance of attenuated solar irradiance (in UV, visible, near IR spectral regions), (b) reflectance of downward scattered radiance field, and (c) thermal emission due to the surface at temperature, T_s. The surface emissivity is unity minus the surface albedo, i.e., (1-r). LOWTRAN requires that the surface albedo be specified, while FASCODE asks for the surface emissivity.

General radiance solutions to the RTE for upward and downward radiances, respectively, are:

$$I(\tau,+\mu,\phi) = I_b(\tau^*,\mu,\phi)\, e^{-(\tau^*-\tau)/\mu} + \int_{\tau}^{\tau^*} J(t,\mu,\phi)\, e^{-(t-\tau)/\mu} \frac{dt}{\mu} \tag{2.8}$$

$$I(\tau,-\mu,\phi) = I_b(o,-\mu,\phi)\, e^{-\tau/\mu} + \int_{o}^{\tau} J(t,\mu,\phi)\, e^{-(\tau-t)/\mu} \frac{dt}{\mu} \tag{2.9}$$

where the I_b are given by the boundary conditions (2.7) and (2.5) above, respectively. Incorporating these boundary conditions, the radiance solutions become:

$$I(\tau,\mu,\phi) = \{\frac{r}{\pi}\left[\pi\mu_o F e^{-\tau^*/\mu_o} + \int_o^1 \int_o^{2\pi} I(\tau^*,-\mu,\phi)\mu d\mu d\phi\right]$$
$$+ (1-r)\ B[T(\tau^*)\}\ \exp-(\tau^*-\tau)/\mu + \int_\tau^{\tau^*} J(t,\mu,\phi)\ e^{-(t-\tau)/\mu} \frac{dt}{\mu} \qquad (2.10)$$

$$I(\tau,-\mu,\phi) = \int_o^\tau J(t,\mu,\phi)\ e^{-(\tau-t)/\mu} \frac{dt}{\mu} \qquad (2.11)$$

In the stream approximation, the multiple scattering contribution to the source function (Eq. (2.4) above) is approximated by assuming constant scattered radiances I^+ and I^- over upward (Ω^+) and downward (Ω^-) hemispheres, respectively, or from Eq. (2.4):

$$J_{MS}(\tau,\mu,\phi) \simeq \frac{\omega_o(\tau)}{4\pi}\left[I^+(\tau)\int_{\Omega^+} P(\Omega,\Omega^+)d\Omega^+ + I^-(\tau)\int_{\Omega^-} P(\Omega,\Omega^-)d\Omega^-\right]. \qquad (2.12)$$

Integrating over the angular scattering functions for the resulting azimuthally averaged backscatter fractions, $\beta(\mu)$, as a function of zenith angle cosine and substituting the corresponding fluxes:

$$I^\pm(\tau) = F^\pm(\tau)/\pi \qquad (2.13)$$

results in

$$J_{MS}(\tau,\pm\mu,\phi) \simeq \frac{\omega_o(\tau)}{\pi}\{F^\pm(\tau)[1-\beta(\mu)] + F^\mp(\tau)\ \beta(\mu)\}. \qquad (2.14)$$

This simple expression for the multiple scattered contribution to the source function is added to the single scattering and thermal emission contributions for the general source function, J (Eq. (2.2)). The source function is then integrated along with the desired path (as in Eqs. (2.10) or (2.11)) to obtain the desired total radiance including the approximated MS contribution.

The evaluation of the approximated MS source function (Eq. (2.14)) requires local fluxes F^+, F^-, backscatter fractions, $\beta(u)$, and single scattering albedos, ω_o. The backscatter fractions are given as functions of zenith angle cosine and asymmetry factor by Wiscombe and Grams (1976) (see Figure 2-2). A small error is introduced by assuming these backscatter fractions for the equivalent Henyey-Greenstein phase function rather than integrating the actual function. The single scattering albedo, $\omega_o(\tau)$, for a given layer with total optical thickness $\Delta\tau$ is:

$$\omega_o(\tau) = \Delta\tau_s/\Delta\tau \tag{2.15}$$

where $\Delta\tau_s$ is the total scattering optical thickness of the layer. Discretizing equation (2.14) for a given layer, N, the contribution of multiple scattering is approximated as:

$$\begin{aligned} J_{SA}^N(\pm\mu) = J_o + \frac{\omega_o^N}{\pi} \{ & F_N^{\pm}[1-\beta^N(\mu,g^N)] \\ & + F_N^{\mp}\beta^N(\mu,g^N)\}. \end{aligned} \tag{2.16}$$

Here the fluxes are taken as the layer mean quantities evaluated at a level halfway through the layer. The asymmetry factor, g, is a measure of the directional scattering and can be evaluated from the phase function.

Once the source function is approximated, the path radiance can be evaluated. Along a path consisting of layers (N) and the layer above (N+1) with transmissions T_N and T_{N+1}, respectively, for example, the emission, E, depends on the path integral of the total source function:

$$E_{N+1}^+ = E_N^+ T_{N+1} + J_{SA}^{N+1}(+\mu)(1-T_{N+1}) \tag{2.17}$$

for downward looking and

$$E_{N+1}^- = E_N^- + (1-T_{N+1})\, J_{SA}^{N+1}(-\mu)T_N \tag{2.18}$$

for upward looking, where the intrinsic layer emission is

$$E_N^{\pm} = (1 - T_N)\, J_{SA}^N(\pm\mu). \tag{2.19}$$

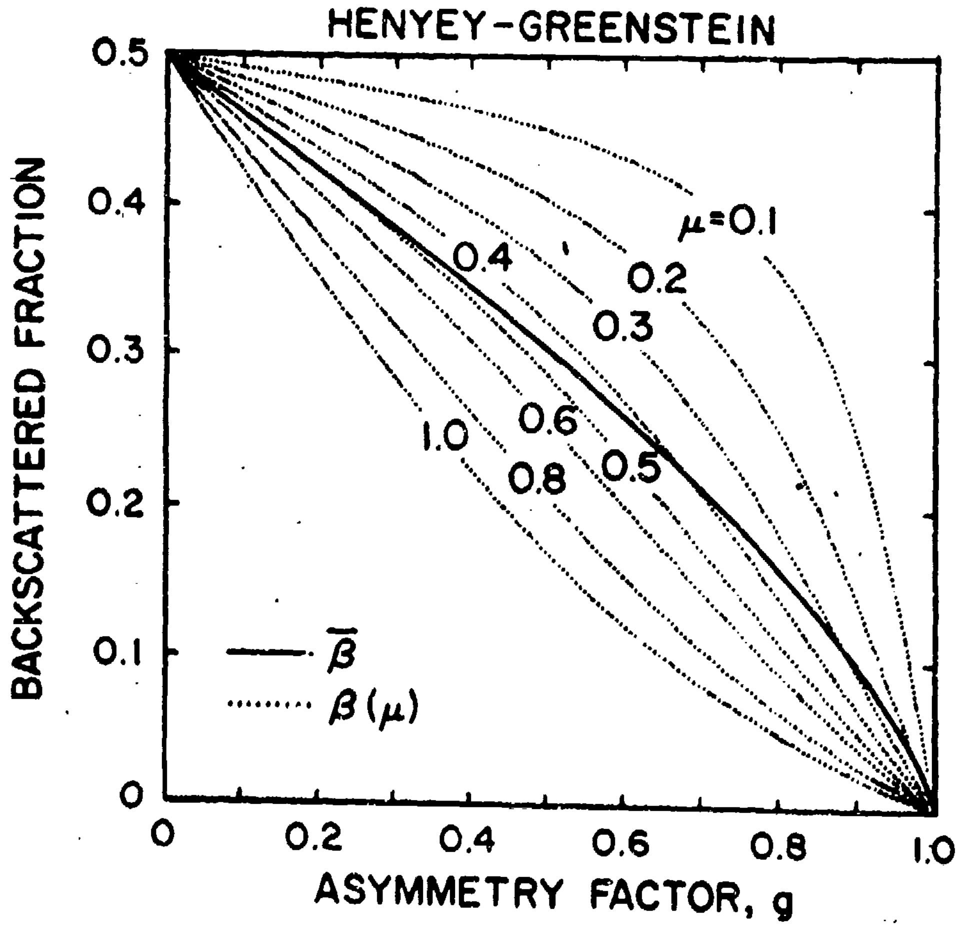


Figure 2-2. Backscattered fractions $\bar{\beta}$ and $\beta(\mu)$ for the Henyey-Greenstein phase function versus the asymmetry factor g for a range of values of μ (Wiscombe and Grams, 1976).

2.2.2 Layer Fluxes

Fluxes approximate the required radiances for evaluation of the multiply scattered source function. Upward and downward fluxes (F^+ and F^-, respectively) for individual isolated layers are evaluated using an appropriate flux parameterization. For example, for solar scattering, the hybrid modified delta eddington approximation (Meador and Weaver, 1980) is used. The chosen flux parameterization also provides intrinsic layer reflection and transmission functions, R and T. These fluxes are calculated using standard two stream parameterization approaches. To accommodate the flux parameterizations, optical properties for the whole atmosphere (i.e., surface to space) are required. The approach for calculating fluxes thus consists of two steps: (1) evaluating local layer (i.e., intrinsic) fluxes for each atmospheric layer, and (2) combining these to obtain the actual flux profiles using the adding method.

Upward and downward layer fluxes for solar radiation are given by:

$$F^+ = Ae^{k\tau} + Be^{-k\tau} + Ce^{-\tau/\mu_o} \tag{2.20}$$

$$F^- = \frac{1}{\gamma_2}\left\{A(\gamma_1-k)e^{k\tau} + B(\gamma_1+k)e^{-k\tau} + Ye^{-\tau/\mu_o}\right\} \tag{2.21}$$

where the appropriate constants are given by:

$$\begin{aligned}
k &= (\gamma_1^2 - \gamma_2^2)^{1/2} \\
A &= [B(\gamma_1+k) + Y]/(k-\gamma_1) \\
B &= (E_1 e^{k\tau^*} + E_2 e^{-\tau^*/\mu_o})/(E_3 e^{k\tau^*} + E_4 e^{-k\tau^*}) \\
C &= \pi\omega_o\left\{\frac{\beta(\mu_o)}{\mu_o} - \gamma_1\beta(\mu_o) - \gamma_2[1-\beta(\mu_o)]\right\}\left(\frac{\mu_o^2}{1-k^2\mu_o^2}\right) \\
Y &= C\left(\gamma_1 + \frac{1}{\mu_o}\right) - \pi F\omega_o\beta(\mu_o)
\end{aligned} \tag{2.22}$$

$$E_1 = Y[1/(\gamma_1 - k) - r/\gamma_2]$$

$$E_2 = \left[-C + \pi F \mu_o r + \frac{rY}{\gamma_2}\right]$$

$$E_3 = (\gamma_1 + k)[1/(k-\gamma_1) + r/\gamma_2]$$

$$E_4 = [1 - r(\gamma_1 + k)/\gamma_2] \tag{2.23}$$

$$\gamma_1 = \frac{-\{1-g^2-\omega_o(4-3g)-\omega_o g^2(4\beta_o+3g-4)\}}{4[1-g^2(1-\mu_o)]}$$

$$\gamma_2 = \frac{\{7-3g^2-\omega_o(4+3g)+\omega_o g^2(4\beta_o+3g)\}}{4[1-g^2(1-\mu_o)]}$$

Here, r is the Lambert surface albedo and the solar zenith angle cosine is μ_o

The transmission and reflection functions used later in the flux adding are given by:

$$R = F^+/\mu_o \pi F$$
$$T = F^-/\mu_o \pi F + \exp^{(-\tau/\mu)} \tag{2.24}$$

For the thermal fluxes, a linear Planck function relation across an atmospheric layer is used. In so doing, the parameterized two-stream solutions for emission from the layer top and layer bottom, and for total transmission and reflection are

$$F^+ = a(PB_t - mQ - B_b)/D$$
$$F^- = a(PB_b + mQ - B_t)/D$$
$$T = a/D \tag{2.25}$$
$$R = uv(e^{\tau l} - e^{\tau l})/D$$

where B_t and B_b are the Planck intensity at the layer top and bottom and

$$
\begin{aligned}
a^2 &= 1 - \omega_o \\
m &= (B_b - B_t)/\tau \\
P &= ve^{\tau_1} + ue^{-\tau_1} \\
Q &= ve^{\tau_1} - ue^{-\tau_1} - a \\
D &= v^2 e^{\tau_1} - u^2 e^{-\tau_1} \\
u &= (1-a)/2 \\
v &= (1+a)/2 \\
\tau_1 &= \sqrt{3}\, a\tau
\end{aligned}
\tag{2.26}
$$

The optical thickness τ and the single scattering albedo ω_o are given by

$$
\begin{aligned}
\tau &= ku + \tau_s(1 - g) + \tau_a \\
\omega_o &= \tau_s(1 - g)/\tau
\end{aligned}
\tag{2.27}
$$

Here k is the gas absorption coefficient (for a particular wavelength and probability interval), u is the gas amount, τ_s is the scattering optical thickness, τ_a is the absorption optical thickness and g is the asymmetry factor for the particulate matter in the layer.

2.2.3 Flux Adding Method

To obtain the actual flux profile throughout the atmosphere, intrinsic layer fluxes are combined algebraically using the adding method. In this method, fluxes, reflections, and transmissions are used to add individual layers together. Composite upward fluxes, ${}^1F_N^+$, and reflection functions R_N^+, obtained upon adding two isolated layers, N and (N-1) are given by:

$$ {}^1F_N^+ = F_N^+ + T_N({}^1F_{N-1}^+ + F_N^- R_{N-1}^+)(1 - R_N R_{N-1}^+)^{-1} \tag{2.28} $$

$$ R_N^+ = R_N + R_{N-1}^+ T_N^2 \,(1 - R_N R_{N-1}^+)^{-1}. \tag{2.29} $$

Analogous equations provide composite downward fluxes and reflection functions, ${}^{1}F_N^-$ and R_N^-, respectively. The composite upward and downward fluxes provide the actual upward and downward fluxes at layer interfaces including the effects of all layers above and below. For example, the upward and downward fluxes at the boundary between layers N and (N+1) are given by:

$$ {}^{2}F_N^+ = ({}^{1}F_N^+ + {}^{1}F_{N+1}^- R_N^+)(1 - R_N^+ R_{N+1}^-)^{-1}, \tag{2.30} $$

$$ {}^{2}F_{N+1}^- = ({}^{1}F_{N+1}^- + {}^{1}F_N^+ R_{N+1}^-)(1 - R_N^+ R_{N+1}^-)^{-1}. \tag{2.31} $$

Once obtained, these fluxes are substituted into Eq. (2.16) above to provide the approximation of the MS source function.

2.2.4 Band model considerations

For LOWTRAN, it is necessary to integrate the spectral radiance values over a finite spectral interval (~ 20 cm^{-1}). The basic problem encountered in the calculation of radiative transfer in low spectral resolution in a hazy or cloudy atmosphere is the coupling between the processes of scattering and absorption due to cloud/aerosol particles and absorption by atmospheric gases. The main difficulty is that the integration over frequency cannot be properly accounted for by the usual band model technique for gaseous absorption because they do not allow for multiple-scattering. A direct line-by-line integration over frequency would be very time consuming. One alternative way of carrying out the frequency integration is to use the "k-distribution method" for homogeneous layers (Arking and Grossman, 1972) and the "correlated k-distribution approximation" for inhomogeneous atmospheres (cf. Wang and Ryan, 1983).

For gaseous absorption, the k-distribution method is comparable to line-by-line calculations (Arking and Grossman, 1972). This method is equivalent to the exponential-sum fitting method (see Wiscombe and Evans, 1977) and to the path length distribution method (see Bakan et al., 1978). However, in general, the latter two methods use scaling approximations to account for atmospheric inhomogeneity while the correlated-k approximation assumes certain relationship between k values at different pressure and temperature levels. The accuracy of the approximation is excellent for the 9.6 μm O_3 band thermal radiation calculations (see Lacis et al., 1979).

Yamamoto et al. (1970, 1971) used finite sums of exponentials to describe the non-gray nature of water vapor absorption and carried out solutions of the equation of transfer for homogeneous band layers using both Chandrasekhar's principles of invariance as well as the discrete ordinate technique. Both techniques require extensive numerical calculations. On the other hand, two-stream approximations together with the correlated-k approximation have been used to study the radiative effects of aerosols (see Hansen et al., 1980). As best summarized recently by Stephens on efficient and accurate radiation parameterizations (1984, p. 862 of the paper): "... only the k-distribution approach can be readily incorporated into scattering models..."

In a homogenous gas layer, the k-distribution function is formerly related to the mean transmission function $T_{\Delta\nu}(u)$,

$$T_{\Delta\nu}(u) \equiv \frac{1}{\Delta\nu}\int_{\Delta\nu} e^{-ku}\, d\nu \equiv \int_0^{\infty} f(k)e^{-ku}dk$$
$$\equiv \int_0^1 e^{-ku}dg \doteq \sum_{i=1}^{n} e^{-k_i u}\Delta g_i \qquad (2.32)$$

where $\Delta\nu$ is the narrow repeated interval (20 cm^{-1} in LOWTRAN) and u is the gas amount. The f(k) for a given gas at a specified $\Delta\nu$ is the probability density function such that f(k)dk is the fraction of the frequency interval for which the absorption coefficient is between k and k+dk. Eq. (2.32) reveals that the transmission depends on the distribution of k-values within $\Delta\nu$, but not on the ordering of the values. The cumulative k-distribution function is g(k), while (k_i, Δg_i) are the discreet sets of values to approximate the integral.

By expressing the band model transmission as the sum of exponentials, the multiple scattering calculation for each component can be performed independently as if it were a monochromatic problem. These are weighted and summed (as in Equation (2.32) to recover the essential band model character of the problem.

The fit of Wiscombe and Evans (1977) has been used for the two LOWTRAN transmission functions of water vapor/uniformly mixed gases, and ozone. The accuracy of the fitting is in general within a few percent for $T > 0.1$. For inhomogeneous atmospheres, we adopt the same scaling approximation used in LOWTRAN, i.e.,

$$k_i(P,\Theta) = k_i(P_o,\Theta_o)\,\frac{P}{P_o}\sqrt{\frac{\Theta_o}{\Theta}}. \qquad (2.33)$$

where Θ_o, P_o are reference temperatures and pressures, respectively.

3. IMPLEMENTATION OF MULTIPLE SCATTERING PARAMETERIZATION

3.1 FASCODE Implementation of the Stream Approximation for Multiple Scattering

3.1.1 Overview

The existing code structure of the FASCODE line-by-line algorithm presents a constraint for the implementation of a multiple scattering capability. In order to optimize computational efficiency and minimize online storage requirements, FASCODE program logic calculates path transmittance and radiance in a single unidirectional pass through the desired atmospheric path. This pass commences with the highest pressure sublayer (i.e., that requiring the least spectral resolution) and progresses monotonically to the lowest pressure sublayer requiring the highest spectral resolution. Cumulative quantities with spectral structure (such as transmittance and radiance) are evaluated by merging the lower resolution results from the previous layer with the higher resolution results of the current layer. While this procedure is appropriate for nonscattered radiance where the local source function for a layer consists solely of contributions from local thermal emission, the methodology is not valid in the presence of multiple scattering. Fundamentally, the local multiply-scattered (MS) source function is composed of contributions scattered from layers, both above and below the current layer in addition to local thermal emission. Therefore, a modification of the FASCODE program logic is required to incorporate the stream approximation (SA) for multiple scattering within FASCODE. The SA efficiently provides an estimate of the local multiply-scattered source function given the availability of a suitable estimate of the profiles of upward and downward flux. Evaluation of the flux profile, however, requires a priori total atmospheric properties such as optical depth and single scattering albedo profiles. This is not possible with the current layer by layer FASCODE algorithm. Once obtained, the source function for the multiply-scattered radiance may be summed along the desired path in analogy to the approach currently used within FASCODE to obtain the thermal emission via summation of the local Planck function contributions.

This apparent inconsistency of FASCODE with multiple scattering is resolved by combining the stream approximation approach with the adding method to obtain the required MS flux profiles. In the adding method, properties of individual layers (such as emission, transmission, and reflection) are

combined algebraically to yield the overall properties of the combined layers. A typical application of the adding method consists of two opposite unidirectional passes throughout the atmosphere. In the FASCODE implementation, the existing upward pass is exploited to set up one part of the adding calculation. This is done subsequent to the existing calculation of optical depths via the combined line-by-line gas absorption and LOWTRAN-based aerosol extinction routines. The upward pass also provides an opportunity to evaluate and merge radiance contributions due to thermal emission only. A downward pass, unique to MS cases, completes the calculation. During the downward pass, actual fluxes will be calculated for each layer, layer multiply-scattered source function evaluated using the stream approximation, and multiply-scattered radiances summed along the desired path. These radiances will be merged with the nonscattered radiance contributions evaluated during the upward pass to yield total cumulative multiply-scattered radiance.

The combined stream approximation/adding method approach for FASCODE is summarized in the flow chart presented in Figure 3-1. The shaded areas denote modifications to FASCODE to accommodate multiple scattering. The unshaded code segment on the left-hand side of the diagram represents the existing non-MS FASCODE algorithm. Within the shaded portion during the upward pass are code modifications to calculate: (a) layer single scatter albedo, ω_o^N, and phase function asymmetry factor, g^N; (b) layer reflection and transmission functions, R_N, T_N, respectively and intrinsic upward and downward fluxes $F_N^{\pm}$ using the two stream approximation; (c) beginning of the adding method for composite upward fluxes and reflection, ${}^1F^+$, R^+, respectively; and (d) layer and merged values of the thermal radiance contribution E_N^o based on the J_N^o source function described above. The downward pass completes the adding method. Details will be described in the following sections. Notably, the time-consuming line-by-line calculations are done once only during the upward pass. The downward pass is a simple merging of precalculated and stored quantities based on algebraic manipulations.

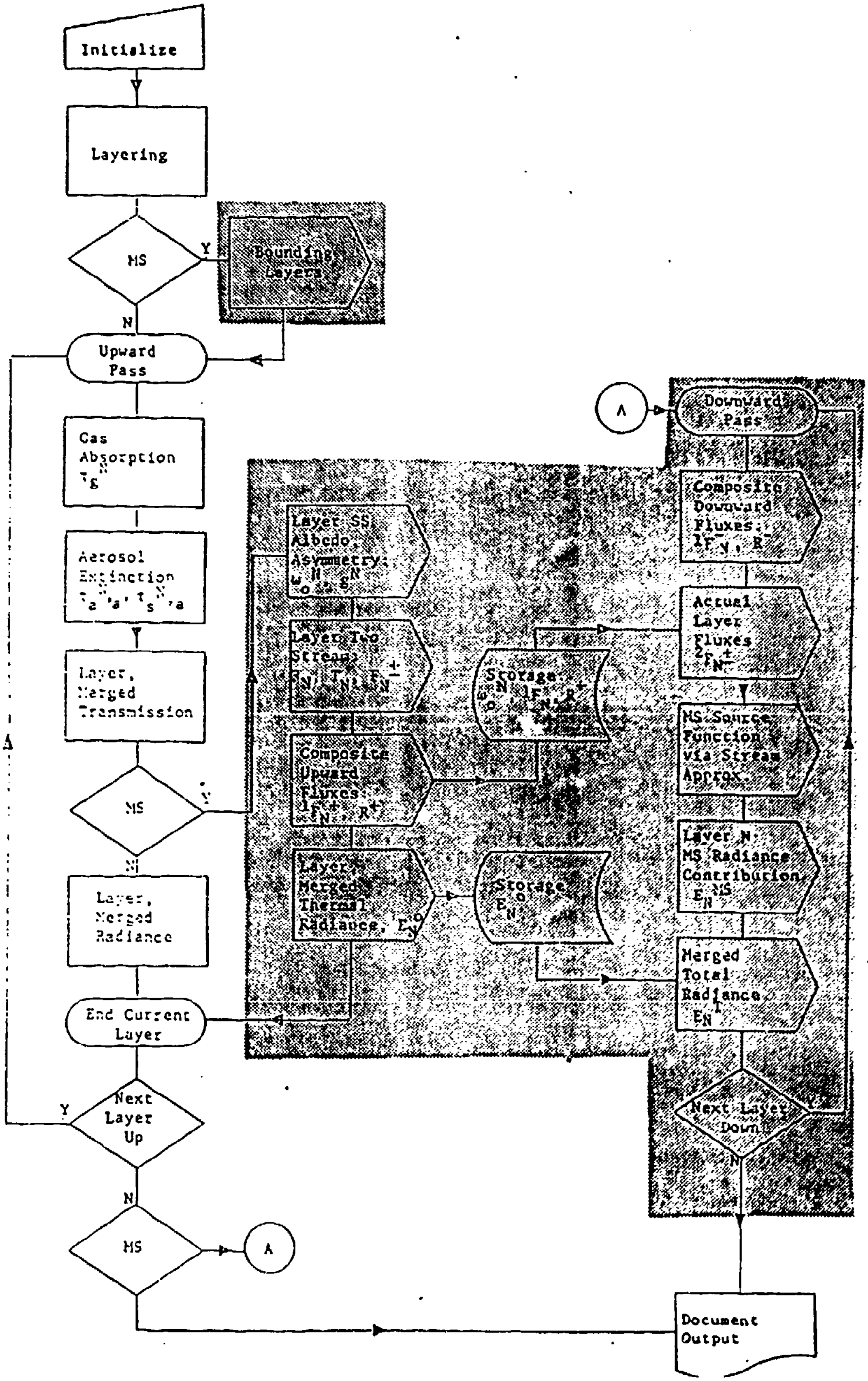


Figure 3-1. FASCODE implementation of stream approximation/adding method.

3.1.2 Adding Method

To illustrate the application of the adding method to calculate the actual flux profiles, consider the layered atmosphere illustrated in Figure 3-2. There are four layers (N-1), (N), (N+1), and (N+2) above an emitting surface (N-2). As each layer is treated during the existing FASCODE upward pass, the following quantities are evaluated:

N+2	T_{N+2}, T_{N+2}, $F^{\pm}_{N+2}$
N+1	R_{N+1}, T_{N+1}, $F^{\pm}_{N+1}$
N	R_N, T_N, $F^{\pm}_N$
N-1	R_{N-1}, T_{N-1}, $F^{\pm}_{N-1}$
N-2	/ / / / / / / / / / / / / / R_{N-2}, F^{+}_{N-2}

Figure 3-2. Schematic of FASCODE model atmosphere layers.

τ_g^N	gas absorption optical depth via line-by-line
$\tau_{g,s}^N$	molecular scattering via LOWFAS
$\tau_{a,a}^N$	aerosol absorption optical depth via LOWFAS
$\tau_{a,s}^N$	aerosol scattering optical depth via LOWFAS
θ^N	mean layer thermodynamic temperature via FASCODE layering.

For a multiple scattering (MS) calculation, the shaded branch of the upward path in Figure 3-1 is selected and the following two additional quantities are calculated:

ω_o^N single scattering albedo = $(\tau_{a,s}^N + \tau_{g,s}^N)/(\tau_g^N + \tau_{a,a}^N + \tau_{a,s}^N + \tau_{g,s}^N)$

g^N phase function asymmetry factor

The asymmetry factor is obtained from a look-up table for the appropriate aerosol model, wavenumber domain, and level.

The asymmetry factor is obtained from a look-up table for the appropriate aerosol model, wavenumber domain, and level.

Next, a simple two-stream approximation is used to evaluate the intrinsic layer fluxes, $F_N^{\pm}$, transmission function (direct and diffuse), T_N, and reflection function, R_N. The intrinsic layer fluxes, $F_N^{\pm}$ are the upward flux at the top and the downward flux from the bottom of the Nth isolated layer, respectively. These are analytical transformations of the form:

$$\{\tau_g^{\,N}, \tau_{a,a}^{\,N}, \tau_{a,s}^{\,N}, g^N, \theta^N\} \longrightarrow \{F_N^{\,+}, F_N^{\,-}, R_N, T_N\}. \tag{3.1}$$

Specific two stream flux formulations for solar and thermal scattering are given in Section 2.2.2. These are evaluated once during the upward pass through FASCODE at increasing spectral resolution with decreasing layer mean pressure, i.e., $\Delta\nu(N+1) < \Delta\nu\ (N)$ where N is layer index numbered consecutively from surface to space, and $\Delta\nu$ is the spectral resolution for each layer determined by the FASCODE algorithm.

Surface emission is treated as the zeroth layer with:

$$\begin{aligned} F_o^{\,+} &= \pi\varepsilon_s B(\theta_s) \\ R_o &= (1 - \varepsilon_s) \\ F_o^{\,-},\ T_o &= 0 \end{aligned} \tag{3.2}$$

where θ_s is the surface temperature and ε_s is the surface emissivity. Likewise, a target at the top of the path may be treated as the Mth layer with:

$$\begin{aligned} F_M^{\,-} &= \pi\varepsilon_t B(\theta_t) \\ R_M &= (1 - \varepsilon_t) \\ F_M^{\,+},\ T_M &= 0 \end{aligned} \tag{3.3}$$

Similar considerations can be applied to treat nonscattering layers above and below the scattering layer system. As noted in the flow chart (Figure 3), an additional modification necessitated in order to accomplish a multipl scattering calculation is the consideration of bounding layers above ar below the altitudes of the nodes of the specified path (i.e., H1 and H2). A minimum of one layer extending from the surface to H1 and from H2 to 15 km (assuming

H2 < 15 km) is included. In order to illustrate application of the adding method, the required relations for the system illustrated in Figure 3-2 are presented explicitly. It has been assumed that multiple scattering contributions above 15 km will be negligible.

3.1.2.1 Upward Adding Pass

The loop begins by adding layer (N-1) to layer (N-2). Subsequent layers are added one at a time until layer (N+2) is reached. The modified upward flux from the combination of (N-2) and (N-1), $^1F_N^+$, consists of three contributions (see Figure 3-2):

i. the intrinsic upward flux from layer (N-1), F^+_{N-1}

ii. the multiple reflection of the intrinsic upward flux from layer (N-2), F^+_{N-2}, transmitted through layer (N-1):

i.e., $$F^+_{N-2} + T_{N-1} + F^+_{N-2}\, T_{N-1}\, R_{N-1}\, R_{N-2} + F^+_{N-2}\, T_{N-1}(R_{N-1}\, R_{N-2})^2 + \ldots$$

$$= F^+_{N-2}\, T_{N-1}(1 - R_{N-1}\, R_{N-2})^{-1}$$

iii. the multiple reflection of the intrinsic downward flux from layer (N-1), F^-_{N-1}, reflected from layer (N-2) and transmitted through layer (N-1):

i.e., $$F^-_{N-1}\, T_{N-1}\, R_{N-2} + F^-_{N-1}\, T_{N-1}\, R_{N-2}(R_{N-1}\, R_{N-2}) + \ldots$$

$$= F^-_{N-1}\, T_{N-1}\, R_{N-2}(1 - R_{N-1}\, R_{N-2})^{-1}$$

These will sum to the composite flux:

$$^1F^+_{N-1} = F^+_{N-1} + T_{N-1}(F^+_{N-2} + F^-_{N-1}\, R_{N-2})(1 - R_{N-1}\, R_{N-2})^{-1} \qquad (3.4)$$

Similar considerations lead to the composite reflection of layers (N-1) and (N-2):

$$R^+_{N-1} = R_{N-1} + R_{N-2}\, T^2_{N-1}(1 - R_{N-1}\, R_{N-2})^{-1} \tag{3.5}$$

Next layer N is added to the composite of (N-1, N-2), resulting in composite values for layer N:

$$^1F^+_N = F^+_N + T_N(^1F^+_{N-1} + F^-_N\, R^+_{N-1})(1 - R_N\, R^+_{N-1})^{-1} \tag{3.6}$$

$$R^+_N = R_N + R^+_{N-1}\, T^2_N\, (1 - R_N\, R^+_{N-1})^{-1} \tag{3.7}$$

This process is repeated for layer (N+1):

$$^1F^+_{N+1} = F^+_{N+1} + T_{N+1}(^1F^+_N + F^-_{N+1}\, R^+_N)(1 - R_{N+1}\, R^+_N)^{-1} \tag{3.8}$$

$$R^+_{N+1} = R_{N+1} + R^+_N\, T^2_{N+1}(1 - R_{N+1} R^+_N)^{-1} \tag{3.9}$$

and layer (N+2):

$$^1F^+_{N+2} = F^+_{N+2} + T_{N+2}(^1F^+_{N+1} + F^-_{N+2}\, R^+_{N+1})(1 - R_{N+2}\, R^+_{N+1})^{-1} \tag{3.10}$$

$$R^+_{N+2} = R_{N+2} + R^+_{N+1}\, T^2_{N+2}(1 - R_{N+2}\, R^+_{N+1})^{-1} \tag{3.11}$$

Since there are no layers above (N+2), the upward composite $^1F^+_{N+2}$ is identically the actual upward flux, i.e.,

$$^2F^+_{N+2} = {}^1F^+_{N+2} \tag{3.12}$$

Calculated composite layer values are required for the evaluation of the composite values of the subsequent layers. These intermediate quantities are merged to the next higher layer's spectral resolution and stored for subsequent use on the downward pass. At the termination of the upward pass, the following quantities have been calculated for each layer and stored for use during the downward pass: (a) the intrinsic layer values, $\omega_o{}^N$, R_N, T_N, F^-_N (the intrinsic upward fluxes are not required), (b) the composite quantities, $^1F^+_N$, R^+, and the nonscattered contribution to emission, E^o_N. These values are stored only at local layer resolution to minimize total memory requirements.

3.1.2.2 Downward Pass

The downward pass is devoted exclusively to the adding method and stream approximation. No additional line-by-line calculations are performed. In analogy to its upward counterpart, downward composite fluxes, ${}^{1}F_{1}^{-}$ and reflectance functions, R_N^{-}, are calculated during the unidirectional downward pass. However, in addition both actual upward and downward fluxes, ${}^{2}F_N^{\pm}$, are calculated from the composite fluxes and reflection functions.

For the topmost layer, no downward composite fluxes are possible (unless there are nonscattering layers above N+2). Therefore, the actual upward and downward fluxes at the interface of layers (N+1) and (N+2) are:

$$ {}^{2}F_{N+1}^{+} = \left({}^{1}F_{N+1}^{+} + F_{N+2}^{-} R_{N+1}^{+}\right)\left(1 - R_{N+2} R_{N+1}^{+}\right)^{-1} \tag{3.13} $$

$$ {}^{2}F_{N+2}^{-} = \left({}^{1}F_{N+2}^{-} + {}^{1}F_{N+1}^{+} R_{N+2}\right)\left(1 - R_{N+2} R_{N+1}^{+}\right)^{-1} \tag{3.14} $$

At this point, actual upward and downward fluxes are available at the boundaries of layer (N+2), facilitating calculation of the multiply-scattered source function, J_{N+2}^{MS}, using the stream approximation (see Equation (2.14)). This source function provides the layer contribution to multiply-scattered emission, E_{N+2}^{MS}. This is added to the thermal contribution E_{N+2}^{O} evaluated during the upward pass.

Proceeding downward, the composite quantities are first calculated by adding the next layer down to the composite above it, for example, the downward composite flux emerging from layer (N+1) and the corresponding downward composite reflection are:

$$ {}^{1}F_{N+1}^{-} = F_{N+1}^{-} + T_{N+1}\left(F_{N+2}^{-} + F_{N+1}^{+} R_{N+2}\right)\left(1 - R_{N+2} R_{N+1}\right)^{-1} \tag{3.15} $$

$$ R_{N+1}^{-} = R_{N+1} + R_{N+2} T_{N+1}^{2}\left(1 - R_{N+1} R_{N+2}\right)^{-1} \tag{3.16} $$

Actual fluxes at the interface of layers N and (N+1) are then obtained from the composite values:

$$ {}^{2}F_{N}^{+} = \left({}^{1}F_{N}^{+} + {}^{1}F_{N+1}^{-} R_{N}^{+}\right)\left(1 - R_{N}^{+} R_{N+1}^{-}\right)^{-1} \tag{3.17} $$

$$^2F^-_{N+1} = (^1F^-_{N+1} + {}^1F^+_N \; R^-_{N+1})(1 - R^+_N \; R^-_{N+1})^{-1} \tag{3.18}$$

For the next layer, N, the procedure is identical, resulting in the composites:

$$^1F^-_N = F^-_N + T_N(^1F^-_{N+1} + F^+_N R^-_{N+1})(1 - R_N R^-_{N+1})^{-1} \tag{3.19}$$

$$R^-_N = R_N + R^-_{N+1} \, T^2_N \, (1 - R_N R^-_{N+1})^{-1} \tag{3.20}$$

and actual fluxes:

$$^2F^+_{N-1} = (^1F^+_{N-1} + {}^1F^-_N \; R^+_{N-1})(1 - R^+_{N-1} \, R^-_N)^{-1} \tag{3.21}$$

$$^2F^-_N = (^1F^-_N + {}^1F^+_{N-1} \, R^-_N)(1 - R^+_{N-1} \, R^-_N)^{-1} \tag{3.22}$$

Finally, the procedure terminates at the surface layer (N-2), layer (N-1) interfaces where:

$$^1F^-_{N-1} = F^-_{N-1} + T_{N-1}(^1F^-_N + F^+_{N-1} \, R^-_N)(1 - R_{N-1} \, R^-_N)^{-1} \tag{3.23}$$

$$R^-_{N-1} = R_{N-1} + R^-_N \; T^2_{N-1}(1 - R_{N-1} \, R^-_N)^{-1} \tag{3.24}$$

Then:

$$^2F^+_{N-2} = (F^+_{N-2} + {}^1F^-_{N-1} \, R_{N-2})(1 - R_{N-2} \, R^-_{N-1})^{-1} \tag{3.25}$$

$$^2F^-_{N-1} = (^1F^-_{N-1} + F^+_{N-2} \, R^-_{N-1})(1 - R_{N-2} \, R^-_{N-1})^{-1} \tag{3.26}$$

In this last step, the upward surface emission flux, F^+_{N-2}, and reflection function, R_{N-2}, are composite quantities since there are no layers below. This completes the downward pass and the multiply-scattered radiance calculation.

3.1.3 Stream Approximation, Source Function, Radiance

Using the stream approximation (SA), the multiply-scattered source function at optical depth, τ, for a path with zenith angle, $\cos^{-1} \mu$, will be given by (see Equation (2.16)):

$$J_{SA}(\tau, \pm\mu) = [1 - \omega_o(\tau)]B(\theta) + \frac{\omega_o(\tau)}{\pi}\{F^{\pm}(\tau)[1 - \beta(\mu)] + F^{\mp}\beta(\mu)\} \quad (3.27)$$

The plus sign is for downward looking paths ($\mu > 0$) while the minus sign is for upward looking paths ($\mu < 0$). In the expression above, $\omega_o(\tau)$ is the single scattering albedo, $B(\theta)$ is the Planck function, and $\beta(\mu)$ is the backscatter fraction for path zenith angle μ. The backscatter fraction is a function of the particulate asymmetry factor at level τ, $g(\tau)$, and is available from Wiscombe and Grams (1976).

For level N, the level source function is given by:

$$\begin{aligned} J_N^{SA}(\pm\mu) = {} & (1 - \omega_o^N)\, B\,(\theta_N) + \\ & \frac{\omega_o^N}{\pi}\{F_N^{\pm}[1 - \beta^N(\mu,g^N)] + F_N^{\mp}\beta^N(\mu,g^N)\} \end{aligned} \quad (3.28)$$

The first term above is due to nonscattered thermal emission, while the second term is due to multiple scattering. Thus, the source function can be written as:

$$J_N^{SA} = J_N^o(\omega_o^N, \theta_N) + J_N^{MS}(\mu, \omega_o^N, g^N, F_N^{\pm}) \quad (3.29)$$

where the thermal emission term J_N^o depends only on local layer properties, and the multiply-scattered term J_N^{MS} requires, in addition to local properties, the local fluxes which depend on the overall path properties. The first term is a generalization of the nonscattering thermal emission source function currently evaluated within FASCODE and may be treated in a like manner.

The path radiance or emission with multiple-scattering is obtained by summing radiance contributions along the path essentially as is currently done with no scattering. Along a path consisting of two layers, layer N and the layer above, N + 1, the emission depends on the path integral of the source function and is given by:

$$E_{N+1}^{+} = E_N^{+}T_{N+1} + J_{SA}^{N+1}(+\mu)(1 - T_{N+1}) \quad (3.30)$$

for downward looking and:

$$E_{N+1}^{-} = E_N^{-} + (1 - T_{N+1})\, J_{SA}^{N+1}(-\mu)T_N \qquad (3.31)$$

for upward looking where:

$$E_N^{\pm} = (1 - T_N)\, J_{SA}^{N}(\pm\mu). \qquad (3.32)$$

With no scattering, $\omega_o^{N,\,N+1} = 0$ and the source function for each layer reduces to the Planck function as in the original FASCODE, i.e.,:

$$\lim_{\omega_0 \to 0} J_{SA}^{N} = B(\theta_N). \qquad (3.33)$$

As described above, the thermal emission source J_N^o can be summed along the path in analogy to the current nonscattering radiance calculation to provide the path thermal emission E_N^o. Evaluation of the multiply-scattered radiance contribution E_N^{MS} for each layer is accomplished via the adding algorithm on the complementary downward pass where it is merged with the previously calculated nonscattered contributions to obtain total radiance.

3.1.4. Description of FASCODE2 with Multiple Scattering

In implementing multiple scattering into FASCODE2, the main considerations were in maintaining the integrity of the existing program, and in making the resultant code as transparent to the user as possible. The first and most constraining element of the existing code, was the use of panels in doing the radiance calculation. This necessitated that any multiple scattering implementation also be adjusted to utilize this methodology.

All of the routines to be listed below, utilize the existing FASCODE method of working with only a "panel" of numbers at a time. This necessitates a great deal of I/O for doing any calculation with multiple scattering, but allows for complete compatibility with the existing structure and execution of FASCODE. Another benefit of this approach, is that the program is compartmentalized, and the user should find no difference in run time for this program with multiple scattering turned off, and the previous version of FASCODE2.

As discussed above, flux adding, used in conjunction with the stream approximation was implemented as the best approach. This involved the extensive

modification of EMINIT, and RADMRG. These routines were modified to merge the composite fluxes and drive the flux-adding during the radiance calculation. The primary additions to the code, were the subroutines FLXADD, FLXDWN, and SRCFCN. FLXADD calculates and adds fluxes for each of the FASCODE layers. This routine is called within the layer loop from both EMINIT, and RADMRG. FLXDWN drives the downward flux adding, and is called from XLAYER after the FASCODE upward path is completed. SCRFCN evaluates the multiple scattered source function, and is called from FLXDWN.

Several secondary routines that were added were MSEMIS, TLEMIS, XLAYMS, FLUXLP, MSIN, and MSOUT. MSEMIS merges the multiple scattered contribution to the radiance for each layer. TLEMIS merges the total multiple scattered radiance contribution obtained from MSEMIS and merges it with the total single scattered radiance calculated within FASCODE. XLAYMS drives the calculation of the radiance contribution from layers above the desired path. FLUXLP merges the fluxes and drives the flux-adding for layers in which radiances are not evaluated. The purpose of these last two routines will be discussed in Section 3.1.5. MSIN reads merged fluxes from the previous layer while MSOUT writes out the merged fluxes for the current layer.

Some minor additions were the functions BETABS, and E3. BETABS evaluates the backscattered fraction for a given angle and asymmetry factor. E3 evaluates the exponential integral E3(x). Some minor changes were also made to EMIN, GETEXT, AERF, EXTDTA, EXABIN, AEREXT, TRANS, LOWTRN, and ATMPTH. EMIN was modified to evaluate the thermal emission, for multiple scattering cases. GETEXT buffers in the asymmetry factors along with the extinction and scattering coefficients. AERF calculates the scattering optical thickness, and the asymmetry factor from the buffered in quantities. EXTDTA now contains the asymmetry factors for each of the LOWTRAN models. EXABIN does the level weighting for the asymmetry factors. AEREXT evaluates the asymmetry factors for each wavenumber. TRANS does the weighted average for the final asymmetry factor result. LOWTRN was modified to read in the asymmetry factors for user-defined aerosols. ATMPTH was modified to determine the multiple scattering path. This will be discussed in the next section.

A flowchart for FASCODE2 with multiple scattering is illustrated in Table 3-1. The structure of FASCODE2 with multiple scattering is outlined in Table 3-2 giving, also, brief descriptions of the altered and added routines. The segment load file and file usage are shown in Tables 3-3 and 3-4, respectively.

Table 3-1

Flowchart of FASCODE Multiple Scattering Routines

Underlined subroutines are modified from the existing FASCODE; others are new subroutines

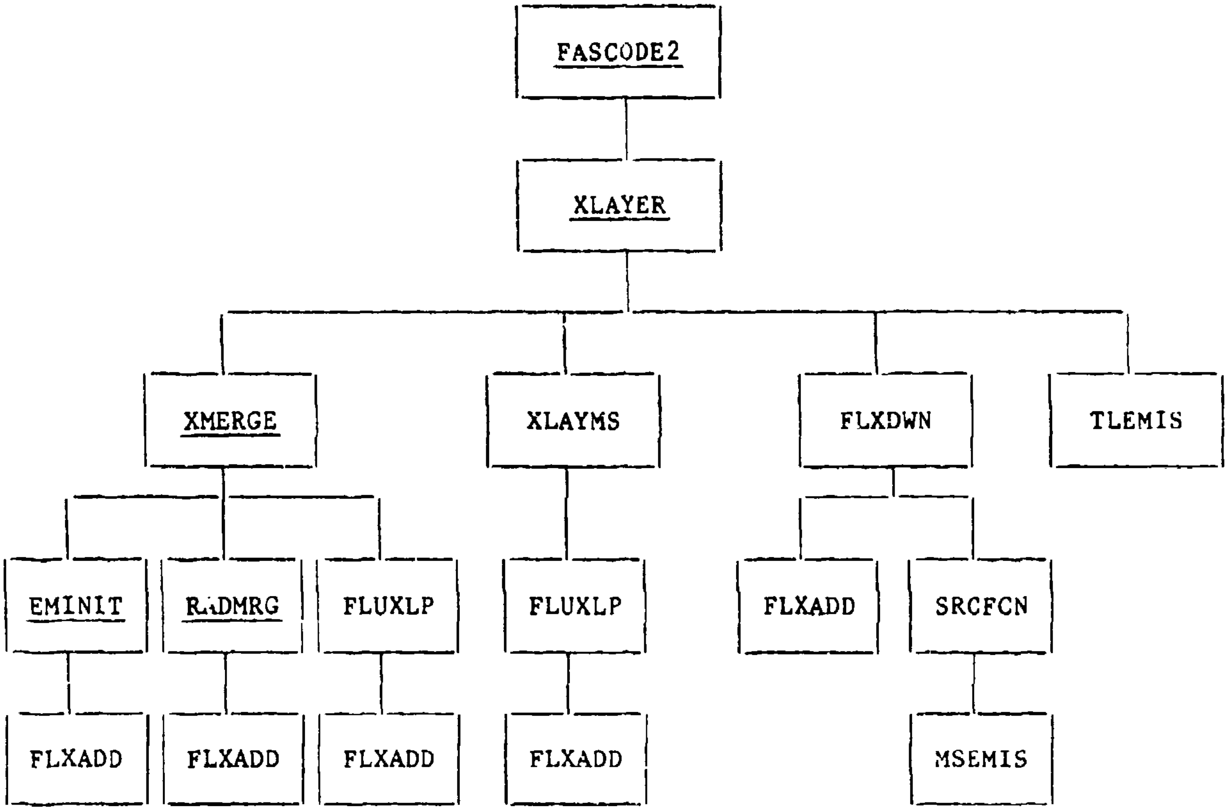


Table 3-2

Description and Segment Load Grouping of FASCODE2 Subroutines

(This listing will contain all the FASCODE routines but will only describe the routines pertinent to the multiple scattering calculation.)

```
FASCOD2*                          Fast Atmospheric Signature Code
 |
 |          /ADRIVE/
 |          /CONSTS/
 |          /FILHDR/
 |          /IFIL  /
 |          /LANCHN/
 |          /LASIV /
 |          /MAIN  /
 |          /MSACCT/*             Multiple Scattering files and parameters
 |          /MSCONS/*             Multiple Scattering flags and constants
 |           BUFIN
 |           BUFOUT
 |           COPYFL
 |           ENDFIL
 |           SKIPFL
 |
 | FLTRFN
 |  |        CNVFLT
 |  |        RDSCAN
 |
 | LASER
 |
 | PLTFAS
 |  |       /AXISXY/
 |  |       /NAME  /
 |  |       /PLTHDR/
 |  |       /POINTS/
 |  |       /TITLOC/
 |  |       /YCOM  /
 |  |        ENDPLT
 |  |        EXPT
 |  |        FSCLIN
 |  |        LINT
 |  |        MNMX
 |  |        TEMPFN
 |  |        TENLOG
 |  |        XNTLOG
```

Legend: /Common Blocks/
(Block Data)
Subroutines

NOTE: "*" designates routines added or modified in the implementation of Multiple Scattering by AER.

Table 3-2 (Cont.)

```
| | AXES
| | |  AXISL
| | |  AXLOG
| | |  AX2
| | BBSCLE
| | FPLINE
| | HEADER
| SCANFN
| |            CKPRNT
| |            CNVREC
| |            CONVSC
| |            INTER
| |            PANLSC
| |            RDSCAN
| |            SHAPEG
| |            SHAPET
| |            SHRKSC
| |            SINCSQ
| TEST
| |           (BTEST)
| XLAYER*                          Controls Layer by Layer Calculation
| |           /ABSORA/
| |           /ASYMMA/*            Aerosol Asymmetry Factors
| |           /LINHDR/
| |           /MLTSCT/*            General Labeled Common for Multiple Scattering
| |           /SCATTA/
| |           /RMRG  /
| |           /XBLF  /
| |            MSCOPY*             Copies Multiple Scattering output files by panels
| |  FLXDWN*                       Controls Layer by Layer Downward Flux Adding
| |  |         AERF*               Evaluates Extinction, Scattering, and Asymmetry
| |  |         BBFN                Computes Black Body Function
| |  |         E3*                 Computes Exponential Integral E3
| |  |         FLXADD*             Calculates and does Adding of Fluxes for Current
| |  |                                 Layer
| |  |         GETEXT*             Reads Extinction, Absorption, and Asymmetry
| |  |         MSIN*               Reads Merged Fluxes from Previous Layer
| |  |         MSOUT*              Writes Merged Fluxes for Current Layer
| |  |         RADFN               Computes Radiation Function
| |  |                             Evaluates Multiple Scattering Source Function
| |  |  SRCFCN*                    and Radiance
| |  |  |      BETABS*             Calculates Back-Scattering Fraction
| |  |  |      MSEMIS*             Merges Multiple Scattered Radiance
```

Table 3-2 (Cont.)

```
|  |
|  | OPDPTH
|  |  |          /ABSORB/
|  |  |          /SCATTR/
|  |  |          /LBLF  /
|  |  |
|  |  | CONTNM
|  |  |  |          XINT
|  |  |  |
|  |  |  | FRNCO2
|  |  |  | |      (BFCO2)
|  |  |  |
|  |  |  | FRN296
|  |  |  | |      (BFH2O)
|  |  |  |
|  |  |  | N2CONT
|  |  |  | |      (BN2)
|  |  |  |
|  |  |  | O2CONT
|  |  |  | |      (O2C)
|  |  |  |
|  |  |  | O3CHAP
|  |  |  | |      (O3CH)
|  |  |  |
|  |  |  | O3HHTO
|  |  |  | |      (O3HHO)
|  |  |  |
|  |  |  | O3HHT1
|  |  |  | |      (O3HH1)
|  |  |  |
|  |  |  | O3HHT2
|  |  |  | |      (O3HH2)
|  |  |  |
|  |  |  | SL296
|  |  |  | |      (BS296)
|  |  |  |
|  |  |  | SL260
|  |  |  | |      (BS260)
|  |  |
|  |  | HIRAC1
|  |  |  |          /FNSH  /
|  |  |  |          (BHIRAC)
|  |  |  |          (BMOLEC)
|  |  |  |          (BSHAPEL)
|  |  |  |          (VOICON)
|  |  |  |           ABSOUT
|  |  |  |           CNVFNV
|  |  |  |           MOLEC
|  |  |  |           PANEL
|  |  |  |           QV
|  |  |  |           RDLIN
|  |  |  |           R1PRNT
|  |  |  |           SHAPEG
|  |  |  |           SHAPEL
|  |  |  |           VERFN
|  |  |  |           XINT
```

Table 3-2 (Cont.)

```
      LBLF4
            (BMOLEC)
            (VOICON)
             CONVF4
             MOLEC
             QV
             RDLIN4
             SHRINK

      NONLTE
            /VBNLTE/

        HIRACQ
            /FNSQ  /
            (BHIRAQ)
            (BMOLEC)
            (BSHAPEL)
            (VOICON)
             ABSOUT
             CNVFNQ
             MOLEC
             PANELQ
             QV
             RDLIN
             R1PRNT
             SHAPEG
             SHAPEL
             VERFN
             XINT

      VIBPOP

      VIBTMP

    OPPATH*
            /BNDRIES/
            /CNTRL  /
            /PATHD  /

      FSCATM*                 Obtains Refractive Path and Calculates Absorber
            /BNDRY /
            /CONSTN/
            /DEAMT /
            /HMOLS /
            /PARMTR/
            /ZOUTP /
            (ATMCON)
             ATMPTH*          Atmospheric Path Driver
             PACK
             WATVAP
```

Table 3-2 (Cont.)

```
||||  FSCGEO
||||  |      ALAYER
||||  |      AMERGE
||||  |      ANDEX
||||  |      AUTLAY
||||  |      EXPINT
||||  |      FDBETA
||||  |      FINDSH
||||  |      FNDHNM
||||  |      HALFWD
||||  |      RADREF
||||  |      REDUCE
||||  |      RFPATH
||||  |      SCALHT
||||
||||  MDLATM*                      Sets up selected Atmosphere
||||  |     /MDLATM/
||||  |     /TRAC  /
||||  |     (MCATMB)
||||  |      CONVRT
||||  |      DEFALT
||||  |      NSMDL
||||  |      RDUNIT
|||
|||  LOWTRN*                       LOWTRAN Driver for Aerosols
|||  |      /CNSTNS/
|||  |      /LCRD1 /
|||  |      /LCRD2 /
|||  |      /LCRD3 /
|||  |      /LCRD4 /
|||  |      /MART  /
|||  |      /MDLZ  /
|||  |      /MODEL /
|||  |      /RAIN  /
|||  |      /TITL  /
|||  |      /USRDTA/
|||  |      /ZVSALY/
|||  |      (TITLE )
|||  |
|||  |  AERNSM
|||  |  |    /MDATA /
|||  |  |    (MARDTA)
|||  |  |    (MDTA  )
|||  |  |    (PRFDTA)
|||  |  |     AERPRF
|||  |  |     MARINE
|||  |  |     STDMDL
|||  |
|||  |  CIRRUS
|||  |
```

Table 3-2 (Cont.)

```
EXABIN*                     Loads the Aerosol Extinction, Absorption and
                                Asymmetry Coefficients for the desired Model
        /EXTD  /*           Stores all the Aerosol Attenuation Coefficients
        (EXTDTA)*           Contains all the Aerosol Attenuation Coefficients
         AB
         AITK
         DEBYE
         DOP
         GAMFOG
         GMRAIN
         INDX

GEO
        /PARMLT/
        /RFRPTH/
         ANDEX
         EXPINT
         FDBETL
         FILL
         FINDSL
         FNDHML
         GEOINL
         LOLAYR
         PACKL
         RADREF
         REDUCL
         RFPATL
         SCALHT

NEWMDL

TRANS*                      Outputs Aerosol Optical Properties for Path
         AB
         AEREXT*            Interpolates Aerosol Attenuation Coeffients for
                                values at Wavenumber ν
         AITK
         DEBYE
         DOP
         GAMFOG
         GMRAIN
         INDX
         TNRAIN

VSA

PATH

TLEMIS*                     Merges Multiple Scattered and Single Scattered
                                Radiance for the Total Path
         EMOUT              Writes Merged Radiance and Transmittance Results
```

Table 3-2 (Cont.)

XLAYMS*		Contols Layer by Layer Calculation for Contributing Scattering Layers Above Desired Path
	AERF*	Evaluates Extinction, Scattering, and Asymmetry
	BBFN	Computes Black Body Function
	EMIN*	Reads Optical Depths and Calculates τ_{gas}
	E3*	Computes Exponential Integ.al E3
	FLUXLP*	Merges Fluxes from Previous and Current Layer
	FLXADD*	Calculates and does Adding of Fluxes for Current Layer
	GETEXT*	Reads Extinction, Absorption, and Asymmetry
	MSIN*	Reads Merged Fluxes from Previous Layer
	MSOUT*	Writes Merged Fluxes for Current Layer
	RADFN	Computes Radiation Function
XMERGE*		Driver for Merging Options
	GETEXT*	Reads Extinction, Absorption, and Asymmetry
	RADFN	Computes Radiation Function
	XMERGI	Driver for Merging Routines using RADINT
ABINIT		Initializes Optical Depth Calculation
	ABSOUT	Writes Merged Optical Depth Results
ABSINT		Merges Optical Depths using General 4-point Interpolation
	ABSOUT	Writes Merged Optical Depth Results
ABSMRG		Merges Optical Depths using Lagrange 4-point Interpolation
	ABSOUT	Writes Merged Optical Depth Results
ADARSL		Adds Absorption and Scattering to Common Blocks for use in a Transmittance Run
	AERF*	Evaluates Extinction, Scattering, and Asymmetry
	GETEXT*	Reads Extinction, Absorption, and Asymmetry
EMINIT*		Initializes Radiance Calculation with First Layer and Drives Layer Flux Calculation
	AERF*	Evaluates Extinction, Scattering, and Asymmetry
	BBFN	Computes Black Body Function
	EMIN*	Reads Optical Depths and Calculates τ_{gas}
	EMOUT	Writes merged Radiance and Transmittance Results
	E3*	Computes Exponential Integral E3
	FLXADD*	Calculates and does Adding of Fluxes for Current Layer
	MSIN*	Reads Merged Fluxes from Previous Layer
	MSOUT*	Writes Merged Fluxes for Current Layer

Table 3-2 (Cont.)

FLUXLP*		Drives Layer Flux Calculation without Radiance
	AERF*	Evaluates Extinction, Scattering, and Asymmetry
	BBFN	Computes Black Body Function
	EMIN*	Reads Optical Depths and Calculates τ_{gas}
	E3*	Computes Exponential Integral E3
	FLXADD*	Calculates and does Adding of Fluxes for Current Layer
	MSIN*	Reads Merged Fluxes from Previous Layer
	MSOUT*	Writes Merged Fluxes for Current Layer
RADINT		Merges Radiance and Transmittance using General 4-point Interpolation
	AERF*	Evaluates Extinction, Scattering, and Asymmetry
	BBFN	Computes Black Body Function
	EMBND	Evaluates Boundary Contribution to Radiance
	EMIN*	Reads Optical Depths and Calculates τ_{gas}
	EMOUT	Writes Merged Radiance and Transmittance Results
RADMRG*		Merges Radiance and Transmittance using Lagrange 4-point Interpolation, and also Drives Layer Flux Calculation
	AERF*	Evaluates Extinction, Scattering, and Asymmetry
	BBFN	Computes Black Body Function
	EMIN*	Reads Optical Depths and Calculates τ_{gas}
	EMOUT	Writes merged Radiance and Transmittance Results
	E3*	Computes Exponential Integral E3
	FLXADD*	Calculates and does Adding of Fluxes for Current Layer
	MSIN*	Reads Merged Fluxes from Previous Layer
	MSOUT*	Writes Merged Fluxes for Current Layer

Table 3-3
Segment Load File for FASCODE2 with Multiple Scattering

```
FASCODE   TREE       FASCOD2-(LAYRS,LASER,SCANFN,PLOTT,
,FLTRFN,TEST)
FASCOD2   GLOBAL     CONSTS,FILHDR,MAIN,IFIL,LAMCHN,LASIV,ADRIVE,
,MSACCT,MSCONS
FASCOD2   INCLUDE    FASCOD2,BUFIN,BUFOUT
*
LAYRS     TREE       XLAYER-(OPPATHS,OPDPTHS,XMERGES,FLUXES,TLEMIS,XLAYMS)
XLAYER    GLOBAL     LINHDR,XBLF,ABSORA,SCATTA,ASYMMA,RMRG,MLTSCT
XLAYER    INCLUDE    XLAYER,MSCOPY
*
OPPATHS   TREE       OPPATH-(FSCATMA,LOWT,PATH)
OPPATH    GLOBAL     CNTRL,BNDRIES,PATHD-SAVE
OPPATH    INCLUDE    OPPATH
*
FSCATMA   TREE       FSCATM-(FSCGEO,MDLATM)
FSCATM    INCLUDE    FSCATM,ATMPTH,ATMCON,PACK,WATVAP
FSCATM    GLOBAL     CONSTN,HMOLS,PARMTR,DEAMT,ZOUTP,BNDRY-SAVE
FSCGEO    INCLUDE    RFPATH,ALAYER,AUTLAY,EXPINT,FINDSH,SCALHT,ANDEX,
,RADREF,HALFWD,FSCGEO,FDBETA,FNDHMN,REDUCE,AMERGE
MDLATM    INCLUDE    MDLATM,NSMDL,MLATMB,CONVRT,RDUNIT,DEFALT
MDLATM    GLOBAL     MLATM,TRAC-SAVE
*
FLUXES    TREE       FLXDWN-(SRCFCN)
FLXDWN    INCLUDE    FLXDWN,RADFN,GETEXT,FLXADD,MSIN,MSOUT,E3,AERF,BBFN
*
LOWT      TREE       LOWTRN-(GEO,EXABIN,TRANS,AERNS,VSA,CIRRUS,NEWMDL)
LOWTRN    INCLUDE    TITLE
LOWTRN    GLOBAL     LCRD1,LCRD2,LCRD3,LCRD4,MODEL,CNSTNS,
,MDLZ,ZVSALY,MART,USRDTA,TITL,RAIN-SAVE
GEO       INCLUDE    GEO,GEOINL,REDUCL,EXPINT,RADREF,SCALHT,ANDEX,
,RFPATL,FDBETL,FNDHML,FINDSL,FILL,LOLAYR,PACKL
GEO       GLOBAL     PARMLT,RFRPTH-SAVE
EXABIN    INCLUDE    EXABIN,EXTDTA,INDX,DEBYE,DOP,AB,CAMFOG,
,AITK,GMRAIN
EXABIN    GLOBAL     EXTD
TRANS     INCLUDE    TRANS,AEREXT,TNRAIN,DEBYE,DOP,INDX,AB,
,GAMFOG,AITK,GMRAIN
AERNS     TREE       AERNSM
AERNSM    INCLUDE    AERNSM,AERPRF,PRFDTA,MARINE,MARDTA,STDMDL,MDTA
AERNSM    GLOBAL     MDATA-SAVE
*
PATH      INCLUDE    PATH
*
XMERGES   TREE       XMERGE-(ABINIT,ABSMRG,ABSINT,EMINIT,RADMRG,RADINT,
,ADARSL,FLUXLP)
XMERGE    INCLUDE    RADFN,XMERGE,GETEXT,XMERGI
ADARSL    INCLUDE    ADARSL,GETEXT,AERF
```

Table 3-3 (Cont.)

```
*
OPDPTHS   TREE      OPDPTH-(HIRAC1,LBLF4,CONTNW,NLTE)
OPDPTH    GLOBAL    LBLF,ABSORB,SCATTR
*
HIRAC1    INCLUDE   HIRAC1,SHAPEL,SHAPEG,VOICON,RDLIN,CNVFNV,PANEL,MOLEC,
,QV,ABSOUT,VERFN,R1PRNT,XINT,BMOLEC,BHIRAC,BSHAPEL
HIRAC1    GLOBAL    FNSH-SAVE
*
LBLF4     INCLUDE   LBLF4,RDLIN4,CONVF4,MOLEC,QV,SHRINK,VOICON,BMOLEC
*
CONTNW    TREE      CONTNM-(SL296,SL260,FRN296,FRNCO2,
,N2CONT,O3CHAP,O3HHT0,O3HHT1,O3HHT2,O2CONT)
CONTNM    INCLUDE   CONTNM,XINT
O3CHAP    INCLUDE   O3CHAP,O3CH
O3HHT0    INCLUDE   O3HHT0,O3HH0
O3HHT1    INCLUDE   O3HHT1,O3HH1
O3HHT2    INCLUDE   O3HHT2,O3HH2
O2CONT    INCLUDE   O2CONT,O2C
SL296     INCLUDE   SL296,BS296
SL260     INCLUDE   SL260,BS260
FRN296    INCLUDE   FRN296,BFH2O
FRNCO2    INCLUDE   FRNCO2,BFCO2
N2CONT    INCLUDE   N2CONT,BN2
*
NLTE      TREE      NONLTE-(HIRACQ,VIBTMP,VIBPOP)
NONLTE    GLOBAL    VBNLTE
HIRACQ    INCLUDE   HIRACQ,SHAPEL,SHAPEG,VOICON,RDLIN,CNVFNQ,PANELQ,
,MOLEC,QV,ABSOUT,VERFN,R1PRNT,XINT,BMOLEC,BHIRAQ,BSHAPEL
HIRACQ    GLOBAL    FNSQ-SAVE
*
ABINIT    INCLUDE   ABINIT,ABSOUT
*
ABSMRG    INCLUDE   ABSMRG,ABSOUT
ABSINT    INCLUDE   ABSINT,ABSOUT
*
EMINIT    INCLUDE   EMINIT,EMIN,EMOUT,MSIN,MSOUT,BBFN,AERF,FLXADD,E3
*
RADMRG    INCLUDE   RADMRG,EMIN,EMOUT,MSIN,MSOUT,BBFN,AERF,FLXADD,E3
*
RADINT    INCLUDE   RADINT,EMIN,EMOUT,BBFN,AERF,EMBND
*
SRCFCN    INCLUDE   SRCFCN,BETABS,MSEMIS
*
TLEMIS    INCLUDE   TLEMIS,EMOUT
*
XLAYMS    INCLUDE   XLAYMS,GETEXT,RADFN,FLUXLP,MSIN,MSOUT,EMIN,EMOUT,
,FLXADD,BBFN,AERF,E3
*
FLUXLP    INCLUDE   FLUXLP,FLXADD,MSIN,MSOUT,BBFN,AERF,EMIN,E3
*
SCANFN    INCLUDE   SCANFN,SHAPEG,RDSCAN,SHRKSC,SHAPET,CONVSC,PANLSC,
,CNVREC,SINCSQ,CKPRNT,INTER
```

Table 3-3 (Cont.)

```
*
FLTRFN    INCLUDE    FLTRFN,RDSCAN,CNVFLT
*
TEST      INCLUDE    TEST,BTEST
*
PLOTT     TREE       PLTFAS-(BBSCLE,HEADER,AXEST,FPLINE)
PLTFAS    GLOBAL     PLTHDR,AXISXY,YCOM,POINTS,TITLOC,NAME
PLTFAS    INCLUDE    PLTFAS,LINT,EXPT,XNTLOG,TEMPFN,TENLOG,MNMX,FSCLIN,
,ENDPLT
*
AXEST     TREE       AXES-(AXISL,AXLOG,AX2)
          END        FASCOD2
```

Table 3-4
File Usage

UNIT NAMES:

TAPE5	-	INPUT
TAPE6	-	OUTPUT
TAPE10	-	Output file containing gas optical depths for current layer. Labeled KFILE.
TAPE11	-	Output file. For FASCODE runs without MS, it contains merged results from previous layer. For multiple scattering runs, it contains the merged total radiance and transmittance for the path. Label alternates between LFILE and MFILE. Always labeled LFILE for final output.
TAPE12	-	Output file. For FASCODE runs without MS, it contains the final merged results. For multiple scattering runs, this file contains the total thermal emission radiance. Label alternates between MFILE and LFILE. Always labeled MFILE for final output.
TAPE19	-	Intermediate output file, containing aerosol coefficients for path above desired path. Only used if upper path is defined. Labeled IMSFIL.
TAPE20	-	Intermediate output file, containing aerosol coefficients for desired path. Labeled IEXFIL.
TAPE21	-	Intermediate output file, containing total layer flux values. Label alternates between ISFILE and LSFILE.
TAPE22	-	Intermediate output file, containing composite layer flux values. Label alternates between JSFILE, KSFILE, and MSFILE.
TAPE23	-	Intermediate output file, containing composite layer flux values. Label alternates between JSFILE, KSFILE, and MSFILE.
TAPE24	-	Intermediate output file, containing total layer flux values. Label alternates between ISFILE and LSFILE.
TAPE25	-	Intermediate output file, containing composite layer flux values. Label alternates between JSFILE, KSFILE, and MSFILE.
TAPE26	-	Intermediate output file. This file holds optical properties for upper path for the upward adding loop, and for the downward loop it contains the final multiple scattered contribution to the radiance for the FASCODE path. Initially labeled IEFILE, labeled KEFILE at end of run.
TAPE27	-	Intermediate output file, containing the multiple scattered contribution to the radiance. Label alternates between IEFILE, JEFILE, and KEFILE.
TAPE28	-	Intermediate output file, containing the multiple scattered contribution to the radiance. Label alternates between IEFILE, JEFILE, and KEFILE.

Note: TAPE10 - TAPE28 are in buffered binary format.

Table 3-4 (Cont.)

UNIT NAMES

KFILE	-	Contains gas optical depths for current layer.
LFILE	-	Contains results of previous layer for FASCODE runs without multiple scattering. Contains final merged results for multiple scattering run.
MFILE	-	Contains final merged results for FASCODE runs without multiple scattering. Contains total single scattered results for multiple scattering runs.
IMSFIL	-	Contains aerosol coefficients for path above desired path.
IEXFIL	-	Contains aerosol coefficients for desired path.
ISFILE	-	Contains total composite fluxes for previous layer.
JSFILE	-	Contains downward composite fluxes for current layer.
KSFILE	-	Contains upward composite fluxes for previous layers during upward adding loop. Contains downward composite fluxes for previous layer during downward adding loop.
LSFILE	-	Contains total composite fluxes for current layer.
MSFILE	-	Contains upward composite fluxes for current layer during upward adding loop. Contains upward composite fluxes for all layers during downward adding loop.
IEFILE	-	Contains τ_{gas} for upper path during upward adding loop. Contains multiple scattering contribution to the radiance from the current layer during downward adding loop.
JEFILE	-	Contains multiple scattering contribution to the radiance from the previous layers.
KEFILE	-	Contains total multiple scattering contribution to the path radiance.

3.1.5 Notes on the Operation of FASCODE2 with Multiple Scattering

In order to use FASCODE2 with multiple scattering, it would be helpful to understand a little about how and why it does the calculation the way it does. Supplemental user instructions are listed in Table 3-5. The first thing that the user will note, is that a new flag appears in Card 1.2. This flag is for turning off and on the multiple scattering sections of the program. As outlined in the user instructions, various other parameters must also be set so that a) aerosols are included, b) radiance is calculated, c) FSCATM is called, and d) normal merging is done.

The next card, is where an understanding of how the calculation is performed can be very useful. Card 1.2a is a new card which is only read if IMS=1. This card includes four quantities, a) TGRND, which is the temperature of the ground (at 0.0 km), b) SEMIS, which is the emissivity of the surface

(at 0.0 km), c) HMINMS, the minimum height for multiple scattering (default = 0.0 km), and d) HMAXMS, the maximum height for multiple scattering (default = 15.0 km). HMINMS and HMAXMS determine the bounds that are placed on the multiple scattering calculation. HMINMS determines the height at which multiple scattering will start. HMAXMS determines the height above which multiple scattering paths are not calculated. If the maximum of the desired path is below HMAXMS, the program will define a path from the maximum of the desired path to HMAXMS. If the maximum of the desired path is above HMAXMS, then HMAXMS is ignored, but the entire path is calculated using multiple scattering. This means that HMAXMS only checks to see if the contribution from above should be added, but does not cut off the multiple scattering calculation at that height. For the case where the minimum of the desired path is above HMAXMS, then no multiple scattering is performed for that path.

For example, if the user defined a slant path from 4.0 to 10.0 km, with HMINMS = 0.0 km and HMAXMS = 15.0 km, the program would first define a new path from 10.0 to 15.0 km, to obtain the downward flux contribution. Secondly, a path from 0.0 to 4.0 km would be defined to obtain the contribution from the layers below 4 km. Then lastly the program would define the path from 4.0 to 10.0 km and calculate the desired radiances, adding in any contributions obtained from the first two calculations. It should therefore be clear that a simple path from 4.0 to 10.0 km using multiple scattering, may actually involve the execution of FASCODE for THREE separate paths. This therefore can increase the run time proportionally.

This example just described, is the worst case scenario. Another case could consider a path from 10 to 30 km, with HMINMS and HMAXMS as before. The program would first define a path from 0.0 to 10.0 km to obtain the contribution from below, and would then do the path from 10 to 30 km using multiple scattering. Yet another possibility, is to define a path from 0.0 to 10.0 km, with HMINMS and HMAXMS as before. The program would first do a path from 10 to 15 km to obtain the contribution from above, and then do the path from 0.0 to 10.0 km. The final possible case, is to define a path from 0.0 to 20.0 km with HMINMS and HMAXMS still set to 0.0 and 15.0 km respectively. This would result in only one path from 0.0 to 20.0 km calculating the multiply scattered radiances.

One thing the user should note, is that in the preceeding examples there was no mention of angles, or tangent paths. That is because this methodology is true without regard to the angle for slant paths, and is true for all tangent paths. For example, if you want to consider a tangent path starting at 25 km with a minimum at 10 km, and a range of 1000 km, leaving HMINMS and HMAXMS as previously defined. The program would first do the slant path from 0.0 to 10 km to obtain the contribution from below, and would then do the desired tangent path.

The following items should be noted by the user:

1) When doing a multiple scattering run, the input file is rewound so it is not possible to string multiple scattering jobs together.

2) Additional paths which are defined by the multiple scattering parameters will increase run time proportionaly.

3) Some coding notes:

   a) The coding which sets and determines the multiple scattering paths is contained in ATMPTH.

   b) The two routines, XLAYMS & FLUXLP were written for the multiple scattering paths which don't require the calculation of radiances.

A test case for FASCODE along with the input and output files is described in Appendix B.

Table 3-5

Supplemental User Instructions for Using FASCODE2 with Multiple Scattering

The following user instruction cards are not a complete FASCODE2 user deck, but only present the changes to existing cards and/or the addition of new cards required for Multiple Scattering runs.

1) CARD 1.2 now appears as follows:

IHIRAC,	ILBLF4,	ICNTNM,	IAERSL,	IEMIT,	ISCAN,	IFILTR,	IPLOT,
5,	10,	15,	20,	25,	30,	35,	40,
4X,I1,	4X,I1,	4X,I1,	4X,I1,	4X,I1,	4X,I1,	4X,I1,	4X,I1,

ITEST,	IATM,	IMRG,	ILAS,	IMS,	IRAD,	MPTS,	NPTS
45,	50,	55,	60,	65,	70,	71-75,	76-80
4X,I1,	4X,I1,	4X,I1,	4X,I1,	4X,I1,	4X,I1,	I5,	I5

where each of the parameters is as defined in the FASCODE2 user instructions, excluding the new flag, IMS which is used for turning on the multiple scattering sections of FASCODE2.

IMS (0,1) flag for multiple scattering
= 0 normal FASCODE run, no scattering
= 1 FASCODE run with multiple scattering

NOTE: the following must also be true for multiple scattering:
a) IAERSL = 1 or 7
b) IEMIT = 1
c) IATM = 1
d) IMRG = 0

2) CARD 1.2a (this card directly follows Card 1.2)

**** Required if IMS = 1, otherwise omit.

TGRND,	SEMIS,	HMINMS,	HMAXMS
1-10,	11-20,	21-30,	31-40
E10.3,	E10.3,	E10.3,	E10.3

Table 3-5 (Cont.)

TGRND	Temperature of surface (degrees Kelvin) (no default value)
SEMIS	Emissivity of surface (no default value)
HMINMS	Minimum height for Multiple Scattering (default = 0.0 km)
HMAXMS	Maximum height for Multiple Scattering (default = 15.0 km)

3) CARD 3.6 (optional card for LOWTRN subroutine) now appears as follows:

(1 to 16) [DUMMY,EXTC(1,I),ABSC(1,I),ASYM(1,I),(I=1,47)]

Format (3(F6.2,2F7.5,F6.4))

where EXTC, and ABSC are as defined in FASCODE2 user instructions, and ASYM is the Aerosol Asymmetry Factor which is required for multiple scattering calculations.

NOTE: When multiple scattering runs are performed, subsequent runs cannot be done using only one input deck. This is due to the rewinding of the input deck during multiple scattering execution. It is therefore required that each multiple scattering run, necessitates its own input deck.

3.2 LOWTRAN Implementation

3.2.1 Overview

In this section, we describe the technical details of incorporating into LOWTRAN 6 the multiple scattering treatment together with the k-distribution method. The procedure and the new code structure are also presented. The existing LOWTRAN 6 program structure is shown in Figure 3-3 (Figure 27 of Kneizys et al., 1983). For simplicity of implementation, we have added only two new subroutines, MSRAD and FLXADD, to handle the k-distribution and multiple scattering. The subroutine FLXADD is called from MSRAD. The functions of MSRAD and FLXADD are shown in Figure 3-4, while the individual elements are described below.

3.2.2 k-Distribution Method

Because of the complicated molecular absorption band structure of the gases, a rigorous frequency integration would require a line-by-line integration which clearly is very time consuming and thus not acceptable for LOWTRAN. Our approach to this problem is the application of the absorption coefficient (k) distribution method (cf. Wang and Ryan, 1983; Stephens, 1984). In a homogeneous gas layer, the k-distribution function is formally related to the mean transmission function $T_{\Delta\nu}(u)$,

$$\begin{aligned} T_{\Delta\nu}(u) &\equiv \frac{1}{\Delta\nu}\int_{\Delta\nu} e^{-ku}\, d\nu \equiv \int_0^\infty f(k)e^{-ku}dk \\ &\equiv \int_0^1 e^{-ku}dg \approx \sum_{i=1}^{n} e^{-k_i u}\, \Delta g_i \end{aligned} \tag{3.34}$$

where $\Delta\nu$ is the narrow repeated interval (20 cm^{-1} in LOWTRAN) and u is the gas amount. The f(k) for a given gas at a specified $\Delta\nu$ is the probability density function such that f(k)dk is the fraction of the frequency interval for which the absorption coefficient is between k and k + dk. Eqn. (3.34) reveals that the transmission depends on the distribution of k-values within $\Delta\nu$ but not on the ordering of the values. The cumulative k-distribution function is g(k), while (k_i, Δg_i) are the discreet sets of values to approximate the integral.

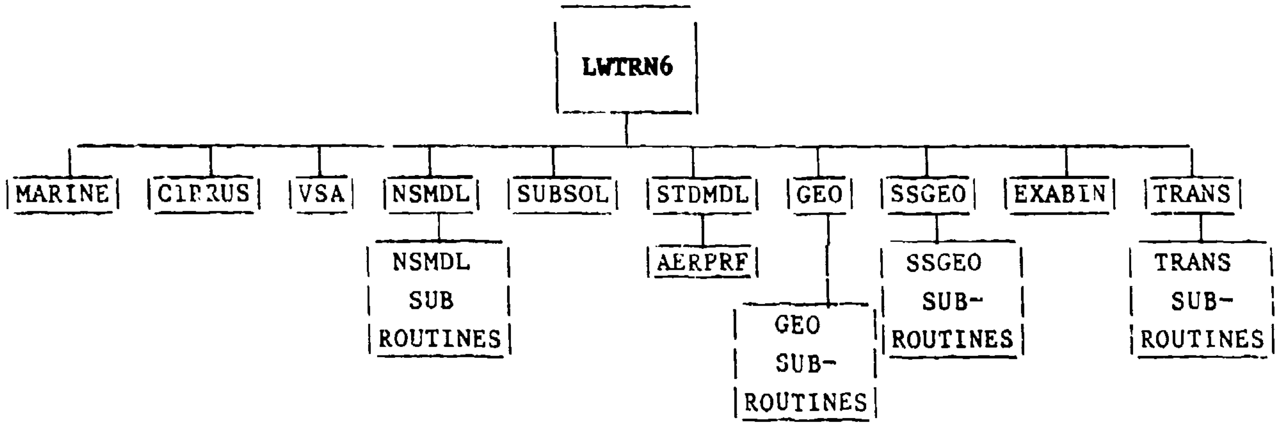


Figure 3-3. LOWTRAN 6 Main Program Structure

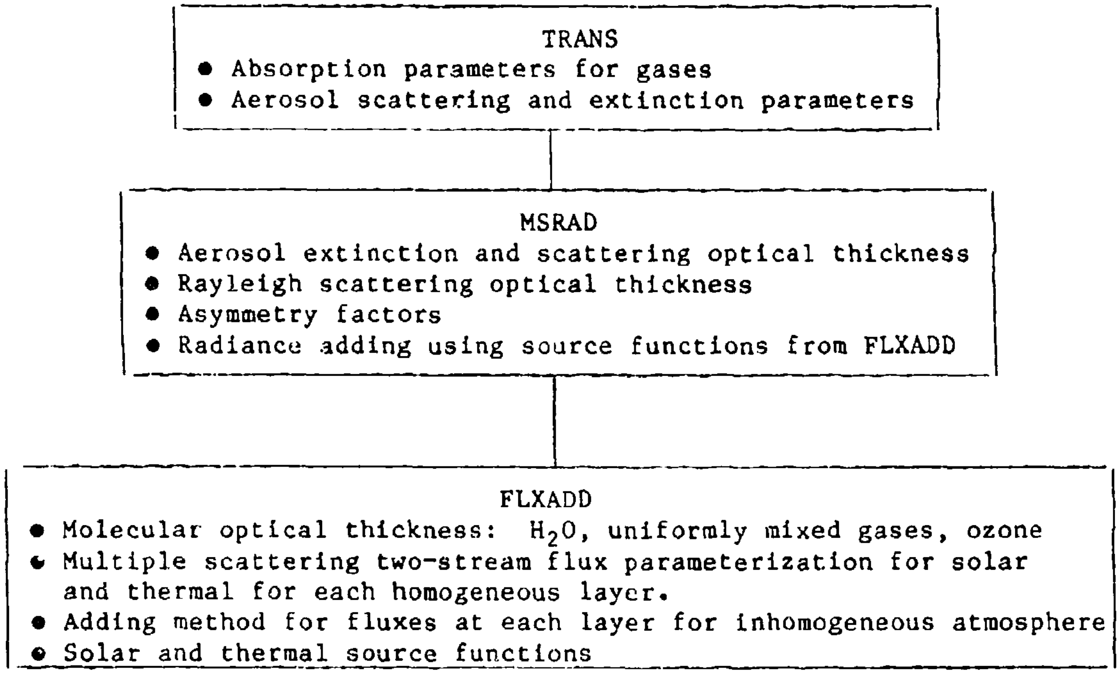


Figure 3-4. Functions of subroutine TRANS, MSRAD, and FLXADD used in the LOWTRAN implementation of multiple scattering.

For the summation in Eq. (3.34) to be useful with LOWTRAN, values for k and Δg must be found to fit the LOWTRAN transmission data for water vapor/uniformly mixed gases (H_2O^+) and ozone (O_3). The transmission for water vapor/uniformly mixed gases and ozone may be expressed as

$$T_1 = T(H_2O^+) = \sum_{i=1}^{M} e^{-k_i u_1} \Delta g_i \tag{3.35}$$

$$T_2 = T(O_3) = \sum_{j=1}^{N} e^{-k_j u_2} \Delta g_j . \tag{3.36}$$

The problem of fitting LOWTRAN transmission data as an exponential sum has been handled successfully by Wiscombe and Evans (cf. Wiscombe and Evans, 1977), using 10 k and Δg values for H_2O^+ and six for O_3. Their k values and associated Δg values are listed in Table 3-6. Plots of the percent transmission error of their fit relative to the LOWTRAN data for both H_2O^+ and O_3 as a function of log10 of the effective optical depth are shown in Figures 3-5 and 3-6.

Making use of the Wiscombe and Evans exponential sum fit of the LOWTRAN transmission data yields values of k_i, k_j, and Δg_i, Δg_j for M = 10, N = 6. However, if $M \neq N$ and $\Delta g_i \neq \Delta g_j$, it is necessary to perform multiple scattering calculations separately for water vapor/uniformly mixed gases (H_2O^+) and ozone (O_3) using two probability (k) loops. This problem is avoided by choosing either the 10 H_2O^+ or 6 O_3 Δg_i values and then expressing the transmission of both H_2O^+ and O_3 as the sum of either 10 or 6 terms. Run time efficiency concerns suggest that both transmissions be expressed as the sum of six exponentials, using the Δg_j values for the ozone fit shown in Table 3-6. Thus, in the LOWTRAN implementation, the transmission function for water vapor is refit to the Δg values for ozone for each path. The transmission as a function of probability is shown in Figure 3-7. (Figure is illustrative only -- actual values are not plotted.)

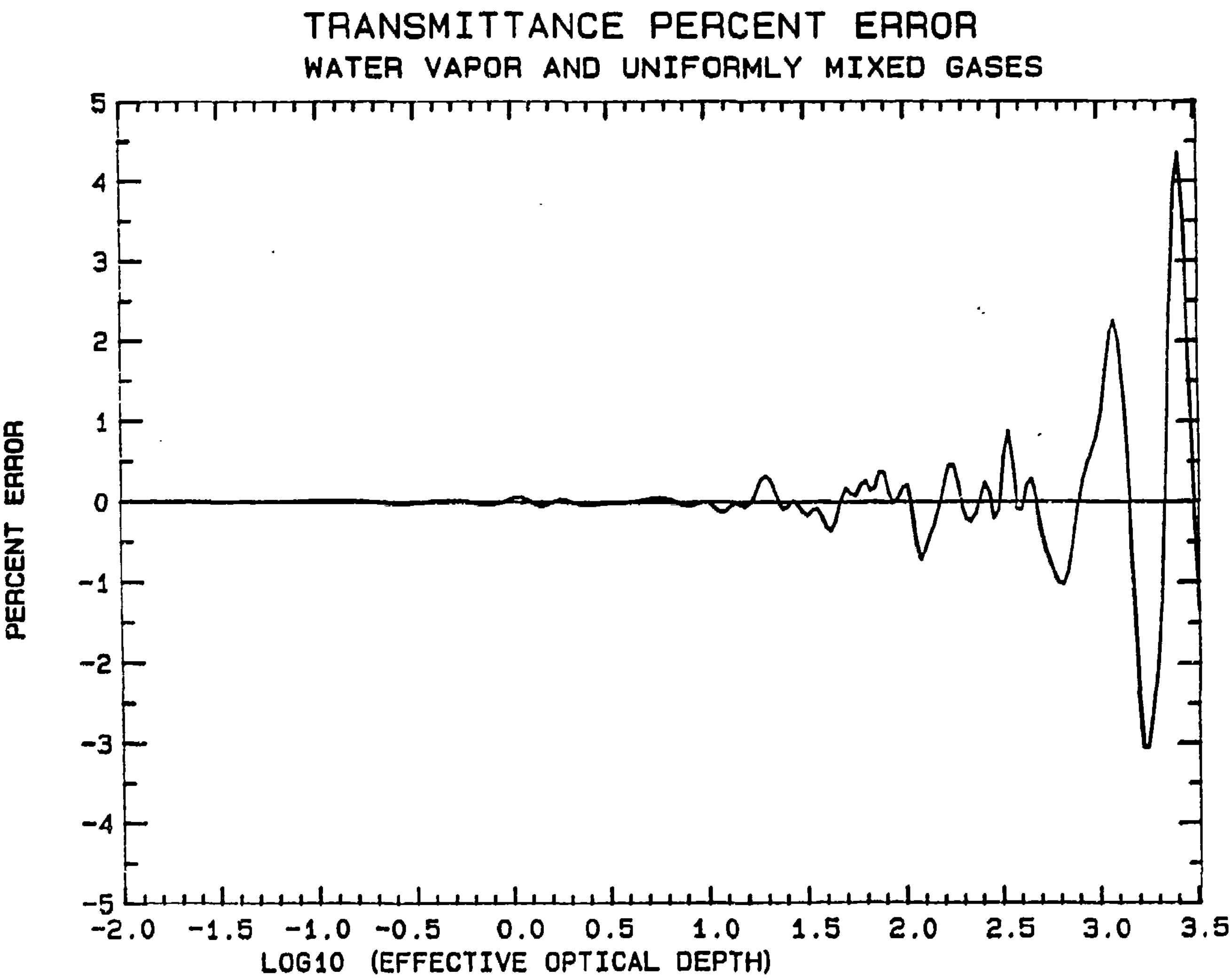


Fig. 3-5 Percent error of transmittance fit for water vapor and uniformly mixed gases relative to LOWTRAN values. Transmittance fit is based on Wiscombe and Evans, 1977

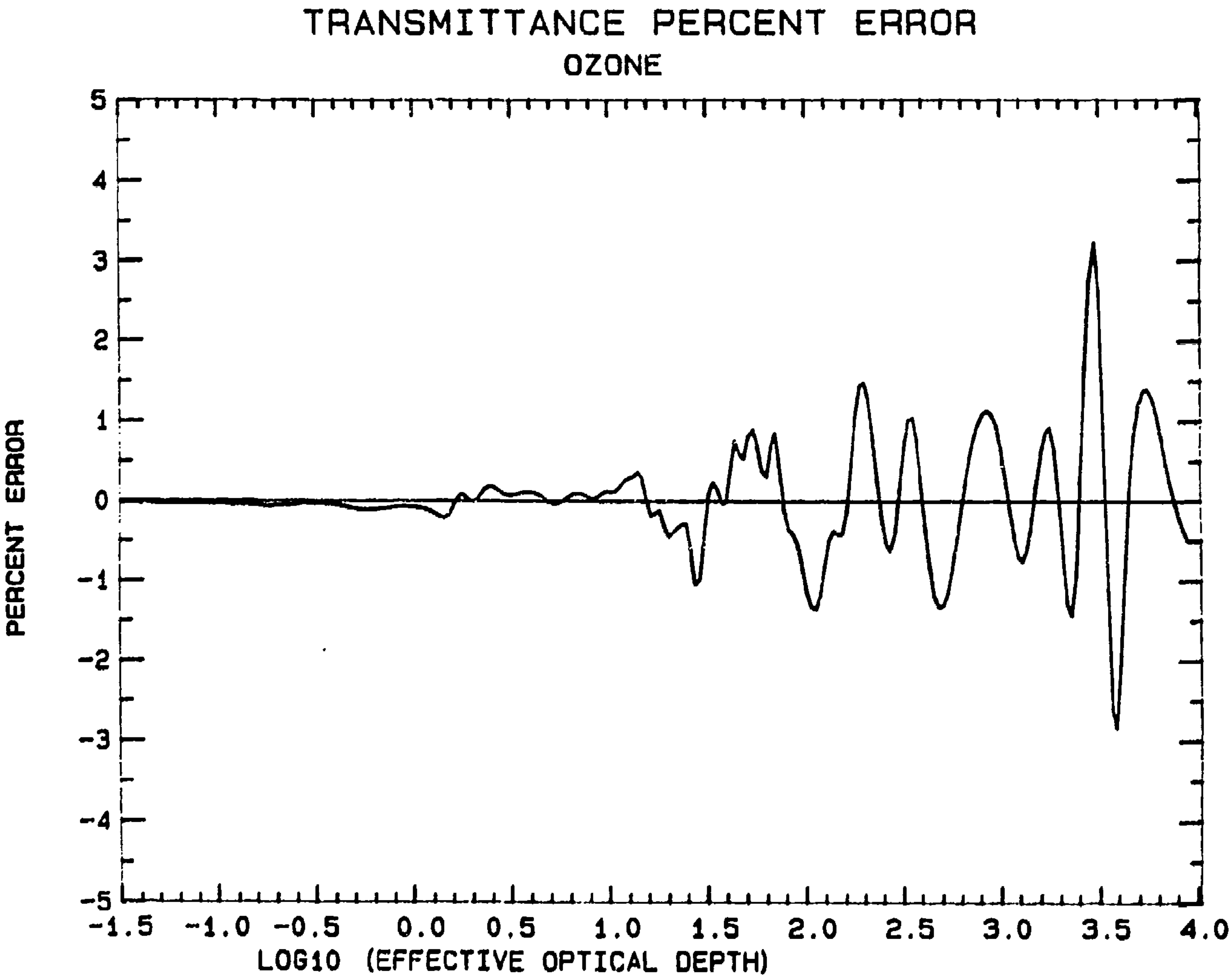
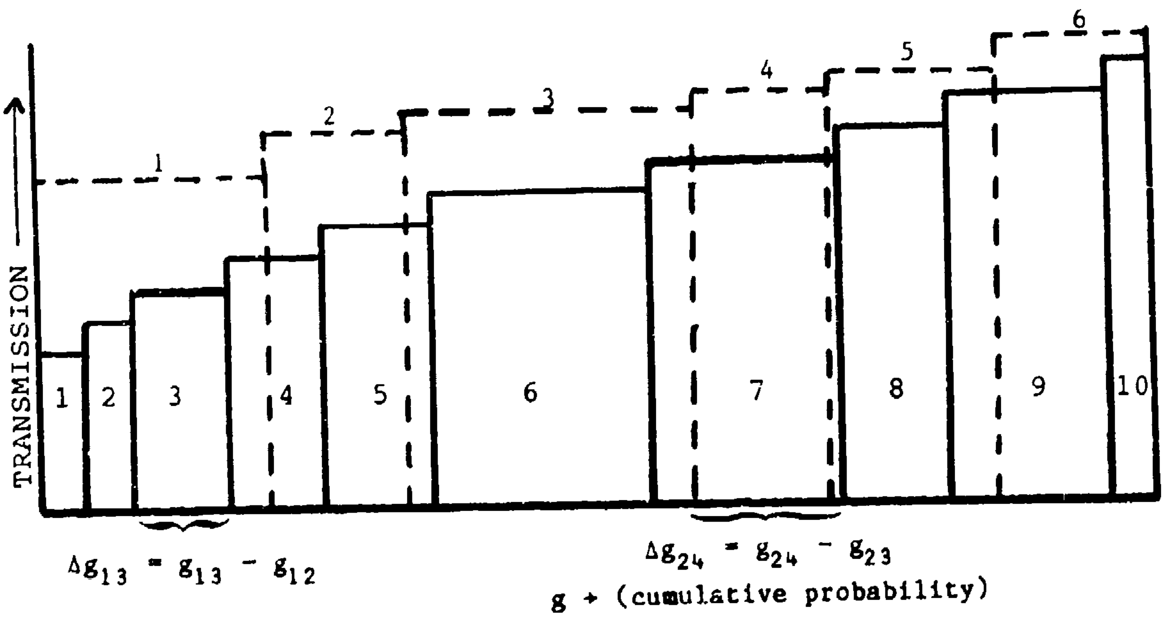


Fig. 3-6 Percent error transmittance fit for ozone relative to LOWTRAN values. Transmittance fit is based on Wiscombe and Evans, 1977.



Legend

——— H_2O^+

---- O_3

g_{1i} = cumulative probability for H_2O^+

g_{2j} = cumulative probability for O_3

Figure 3-7. Transmission vs. cumulative probability for Wiscombe and Evans (1977) fit to LOWTRAN H_2O^+ and O_3 transmission values. (Figure does not depict actual transmission values.)

As an example, the refit H_2O^+ transmission for the first of six components may be expressed as

$$T'_{11} = [T_{11}\,\Delta g_{11} + T_{12}\,\Delta g_{12} + T_{13}\,\Delta g_{13} + T_{14}(g_{21} - g_{13})]/\Delta g_{21}, \tag{3.37}$$

where $T_{1i} = e^{-k_i u_1}$, $i = 1, 10$, so that $T(H2O^+) = T1 = \sum_{i=1}^{6} T'_{1i}\,\Delta g_i$. The total molecular transmission for H_2O^+ and O_3 for a particular layer for some small frequency interval is now

$$T_1 \cdot T_2 = [\sum_{i=1}^{6} e^{-k'_i u_1}\,\Delta g_i] \cdot [\sum_{i=1}^{6} e^{-k_i u_2}\,\Delta g_i]. \tag{3.38}$$

Assuming no overlap of gas absorption, the many cross terms may be eliminated, resulting in

$$T_1 \cdot T_2 \equiv \sum_{i=1}^{6} e^{-(k'_i u_1 + k_i u_2)}\,\Delta g_i. \tag{3.39}$$

Figure 3-8 compares the product of the water vapor and ozone obtained from: (1) the intrinsic LOWTRAN band model, (2) the k-distribution fit including overlap terms (Eqn. (3.38)), and (3) the k-distribution fit assuming no overlap terms (Eqn. (3.39)), i.e., eliminating cross terms. This calculation is for the near surface layer of a US standard atmosphere run and covers the spectral range from about 6.7 to 20 μm. It can be seen that there is some difference between the calculated transmission but very little of practical consequence for the multiple scattering calculation.

The individual components of the combined gas ($H2O^+ + O_3$) molecular absorption transmission can thus be expressed by

$$T_i = T'_{1i} \cdot T_{2i}, \quad i = 1, 2, \ldots 6. \tag{3.40}$$

The jth component of the optical thickness of a given layer due to molecular absorption is

$$\tau_u = -\ln(T_j). \tag{3.41}$$

T_j is added to the molecular continuum, aerosol extinction, and molecular scattering optical thickness to determine the total optical thickness for each k value and layer in FLXADD.

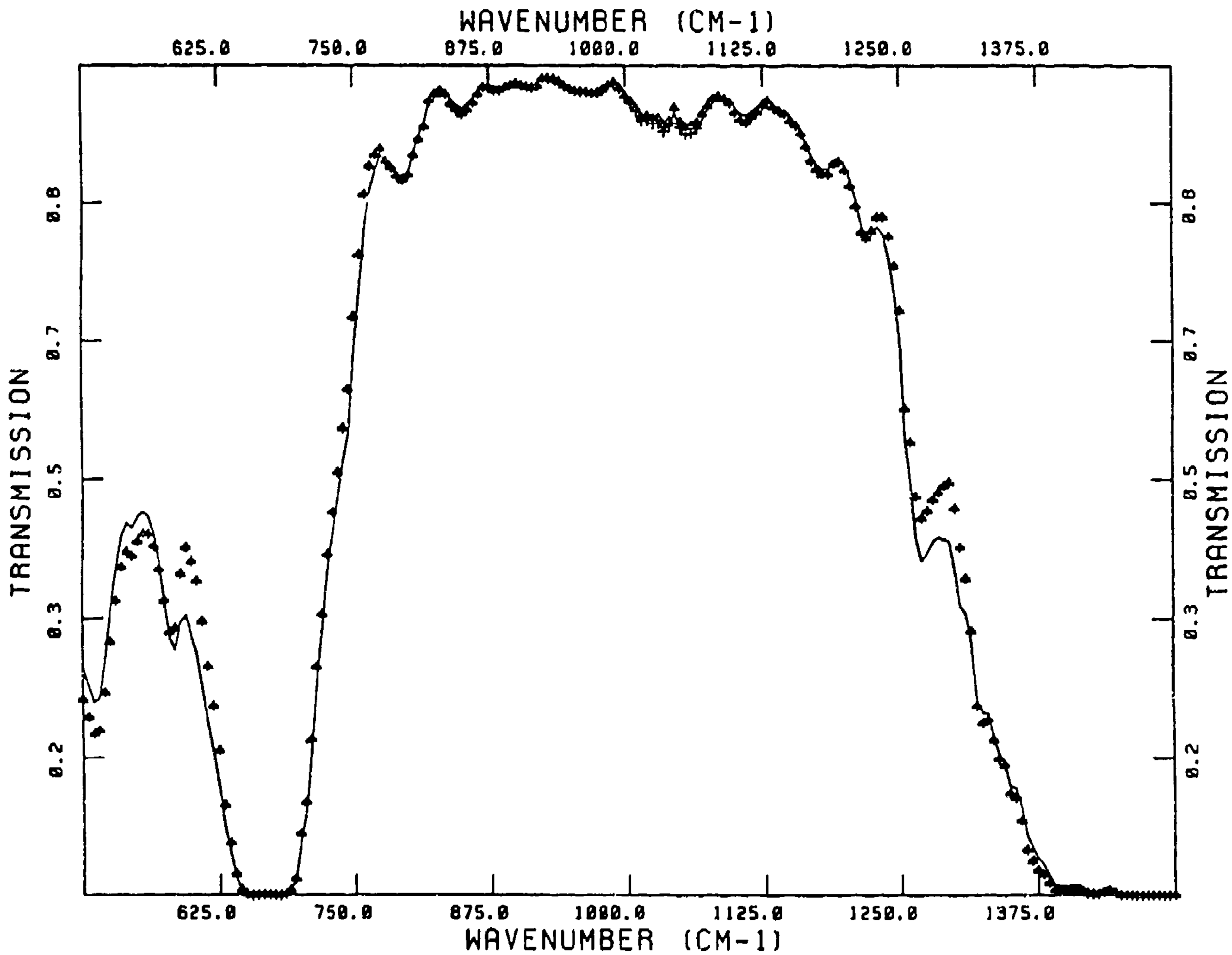


Fig. 3-8. Comparison of LOWTRAN transmission (line) to that calculated from the k-distribution model assuming no overlap (+) and including overlap (Δ).

It is important to note that the k-distribution transmittances are employed only in the determination of the multiply scattered source function. The adding of radiances based on the source function depends on the original LOWTRAN transmissions. Thus, errors in the combined k-distribution/stream approximation approach for multiple scattering are not propagated beyond the approximate multiple scattering approach.

Table 3-6

The Set of k_i and Δg_i Values Used to Approximate the LOWTRAN 6 Transmission Data

i	k_i	Δg_i
I. Water Vapor/Uniformly Mixed Gases		
1	1.718754×10^{-2}	1.233690×10^{-4}
2	2.490766×10^{-1}	4.614758×10^{-3}
3	2.328222	2.404693×10^{-2}
4	7.744676×10^{-1}	2.772890×10^{-2}
5	2.229876×10^{-1}	5.409872×10^{-2}
6	4.438688×10^{-2}	2.119191×10^{-1}
7	1.081388×10^{-2}	2.776904×10^{-1}
8	3.054533×10^{-3}	3.089278×10^{-1}
9	1.258653×10^{-3}	9.072606×10^{-2}
10	0.000000	1.240893×10^{-4}
II. Ozone		
1	4.736517×10^{-1}	7.395116×10^{-2}
2	3.823806×10^{-2}	5.557539×10^{-1}
3	7.424869×10^{-3}	2.476504×10^{-1}
4	1.785435×10^{-3}	8.688930×10^{-2}
5	4.336295×10^{-4}	3.565867×10^{-2}
6	0.000000	1.385517×10^{-4}

3.2.3 Inhomogeneous Atmosphere

For inhomogeneous atmospheres, we adopt the same scaling approximation used in LOWTRAN (see Eqn. 2.21):

$$k_i(P,\Theta) = k_i(P_o,\Theta_o)\,\frac{P}{P_o}\sqrt{\Theta_o/\Theta}$$

We use the same adding method discussed in Section 3.1.2 to calculate the thermal radiation flux in an inhomogeneous atmosphere. Basically, the parameters used are F^+, F^-, T, and R, as presented in Section 3.1.2.

3.2.4 Stream Approximation, Source Function, and Radiance Calculation

Again, we use the same procedures discussed in Section 3.1.3. to calculate the radiance from the source function and stream approximation.

The multiple scattered contribution to the source function is approximated by (Eqn. 2.14, 2.2, 2.3, 2.10, 2.11).

$$J_{MS}(\tau,\pm\mu,\phi) \simeq \frac{\omega_o(\tau)}{\pi}\left\{F^{\pm}(\tau)[1-\beta(\mu)] + F^{\mp}(\tau)\,\beta(\mu)\right\}. \tag{2.14}$$

The total source function is:

$$J(\tau,\mu,\phi) = J_o(\tau,\mu,\phi) + J_{MS}(\tau,\mu,\phi) \tag{2.2}$$

where:

$$J_o(\tau,\mu,\phi) = \frac{\omega_o(\tau)}{4\pi}\,\pi F e^{-\tau/\mu_o}\,P(\Omega;-\Omega_o) + \left[1-\omega_o(\tau)\right]\,B[\Theta(\tau)] \tag{2.3}$$

The single scattered contribution to J_o above is taken directly from the existing LOWTRAN single scattering coding. (Actually the summed multiply scattered radiance is added to the summed singly scattered radiance.)

One essential difference between the multiple scattering radiance implementation and the previous single scattering version is the treatment of surface reflection. Through the surface boundary condition, surface reflection affects the flux profile and hence source function throughout the atmosphere. From the radiance solutions:

$$I(\tau,\mu,\phi) = \{\frac{r}{\pi}[\pi\mu_o F e^{-\tau^*/\mu_o} + \int_o^1 \int_o^{2\pi} I(\tau^*,-\mu,\phi)\mu d\mu d\phi]$$

$$+ (1-r)\, B[\Theta(\tau^*)\} \exp-(\tau^*-\tau)/\mu + \int_\tau^{\tau^*} J(t,\mu,\phi)\, e^{-(t-\tau)/\mu} \frac{dt}{\mu} \qquad (2.10)$$

$$I(\tau,-\mu,\phi) = \int_o^\tau J(t,\mu,\phi)\, e^{-(\tau-t)/\mu} \frac{dt}{\mu} \qquad (2.11)$$

It can be seen that surface reflection can increase both upward and downward radiances through the source function. For upward radiances, there is a more drastic difference between the standard LOWTRAN treatment and the implemented multiple scattering version. This concerns reflection of downward scattered radiance from the surface and back to a downward looking observer (the second term in the brackets in Equation (2.10)). This contribution is not included in standard LOWTRAN although the reflected attenuated direct solar term is (i.e., the first term in Equation (2.10)).

3.2.5 Description of LOWTRAN6 with Multiple Scattering

The addition of multiple scattering to LOWTRAN6 has been made with a minimum of changes to the source code and input deck. Only one new input parameter, IMULT, has been added. IMULT, read as the last input on card 1, is set to zero for the original LOWTRAN6 with single scattering and one for the AER LOWTRAN6 with multiple scattering. If aerosols are not included (clear sky case), the original LOWTRAN6 is executed, independent of the value of IMULT.

Source code changes were made primarily in the main program LWTRN6 and in subroutines TRANS, with some additions to EXABIN, AEREXT, EXTDTA, and RFPATH. Subroutines MSRAD, FLXADD, and ALEVEL and functions BETABS and PLANCK were added.

The main program has been altered to allow the path geometry calculations (called from subroutine GEO) to be accessed twice, once for the original LOWTRAN single scatter path and once for the entire atmosphere, required for computation of the multiply scattered radiance. The reason for the second path geometry call is that the thermal and solar source functions used to determine the multiply scattered radiance contribution are functions of the

upward and downward flux at each layer. The multiply scattered flux at a given layer will, in part, be determined by radiation from all atmospheric layers, even those above or below the layers between the observer and target. To calculate the fluxes at each layer, it is therefore necessary to add the flux contributions from the surface up to space, and back down to the surface again. This adding procedure, executed in the new subroutine FLXADD, is discussed in detail in Sections 3.1.2.1 and 3.1.2.2.

A flag (variable ITEST) has been incorporated into RFPATH for the purpose of isolating the refracted viewing path zenith angle for each layer, as opposed to the solar zenith angle, calculated for the solar cases in a later pass through RFPATH.

A number of changes were incorporated into subroutine TRANS. After calculating the cumulative path parameters used in the original LOWTRAN6, it calls MSRAD, where the aerosol scattering and extinction, H_2O continuum and Rayleigh scattering optical thickness for each layer are calculated. The asymmetry factor for each layer is also calculated based on model extinction and absorption data added to EXABIN, AEREXT, and EXTDTA, and aerosol effective absorber amounts for the four vertically spaced aerosol regions. MSRAD calls subroutine FLXADD.

Subroutine FLXADD calculates the six degraded k components of the H_2O/ uniformly mixed gas transmission for each layer, as well as the molecular absorption optical thickness. It is then added to the continuum, aerosol extinction, and molecular scattering optical thickness from MSRAD to provide the total optical thickness for each layer and k-value, as well as the corresponding single scatter albedo. The diffuse flux contribution for each isolated layer and k-value is computed from the applicable two-stream approximation, either solar or thermal, and combined in the flux adding routine to determine the total upward and downward flux for each layer for each k value. The diffuse solar downward flux is summed over k value and returned to evaluate the surface reflected downward diffuse solar flux. Function PLANCK returns the black body radiance for a particular wavenumber and temperature in units of Wcm^{-2} $sterad^{-1}/cm^{-1}$, while subroutine ALEVEL returns the layer number corresponding to a particular height, the top layer of the atmosphere being layer 1. Knowing the upward and downward fluxes as well as the backscatter parameter β returned from function BETABS, the multiple scattered source function can be determined.

Returning to MSRAD, the radiance is summed over the viewing path (between H1 and H2) and k-values to provide the multiply scattered diffuse radiance contribution. For a downward looking (upward radiance) calculation, the multiply scattered radiance at the upper boundary may be expressed by

$$I^{+}(n_t) = \sum_{k=1}^{6} \left\{ (1-T'_{n_t})\, S(k,n_t) + \sum_{i=n_t}^{n_b-1} (T'_{i+1} - T'_i)\, S\,(k,i+1) \right\} \Delta g_k + I_s \quad (3.39)$$

where n_b is the bottom layer, n_t the top layer, $S(k,i)$ the source function for a particular k value and layer i. T'_i is the transmission from the upper boundary (H2) through layer i along the viewing path. The total upward radiance also includes I_s, a direct solar reflection surface contribution or surface thermal emission term, which for the new AER LOWTRAN includes the contribution due to the reflection of the single and multiple scattered solar radiance. For a thermal case,

$$I_s = B_s\, T_t\, \varepsilon \quad (3.40)$$

where B_s is the black body function for a given surface temperature and frequency, T_t is the total atmospheric transmissivity, and ε is the surface emissivity. For the old LOWTRAN (single scatter) solar case,

$$I_s = a_s\, \mu_o T_t S/\pi, \quad (3.41)$$

where a_s is the surface albedo, μ_o the cosine of solar zenith angle at the surface, and S the direct solar intensity at the surface. With multiple scattering (IMULT=1), the single and multiple scatter reflection terms are added, so that

$$I_s = a_s \mu_o T_t S/\pi + a_s F_s^- \, T_t/\pi, \quad (3.42)$$

where F_s^- is the downward diffuse flux at the surface.

For an upward looking (downward radiance) case, the multiply scattered radiance is expressed by

$$I^{-}(n_b) = \sum_{k=1}^{6} \left\{ (1 - T_{n_b})\, S(k,n_b) + \sum_{i=n_b}^{n_t+1} (T_i - T_{i-1})\, S\,(k,\, i-1) \right\} \Delta g_k, \quad (3.43)$$

where T_i is the transmission from the lower boundary (H1) through layer i along the viewing path. At this point, the LOWTRAN6 path parameters are reloaded, and TRANS is executed once more for the single scatter LOWTRAN6 case. The single scatter diffuse radiance is added to the multiple scatter

term and the boundary radiance contributions (if any) to yield the total thermal radiance, while the solar/lunar radiance is the sum of the single and multiple scatter terms plus a surface reflection term where applicable. MSRAD and FLXADD are not called for the LOWTRAN6 single scatter case.

Figures 3-9 and 3-10 are flow charts of subroutines TRANS, MSRAD, and FLXADD.

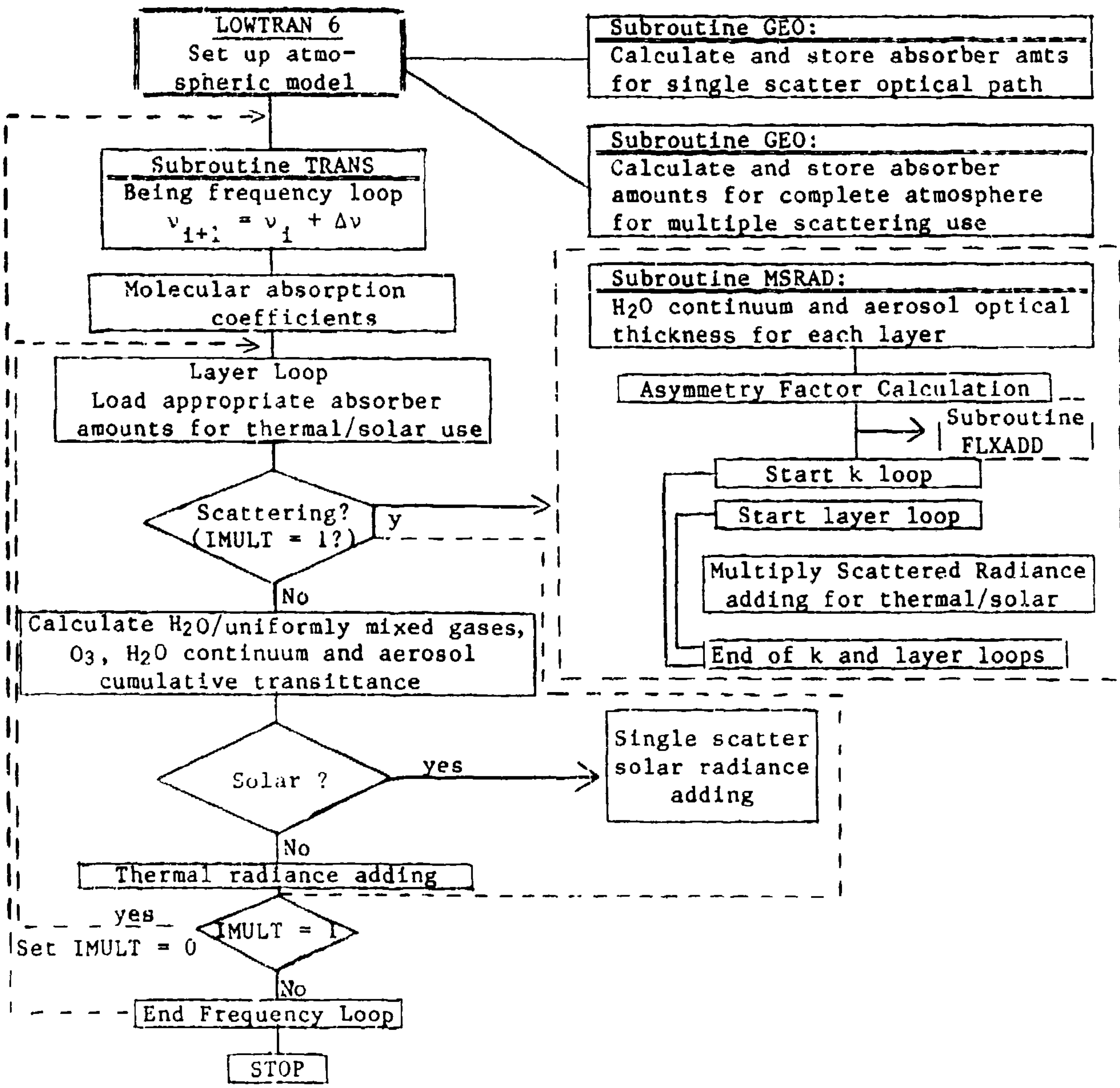


Figure 3-9. Flowchart of Subroutines TRANS and MSRAD.

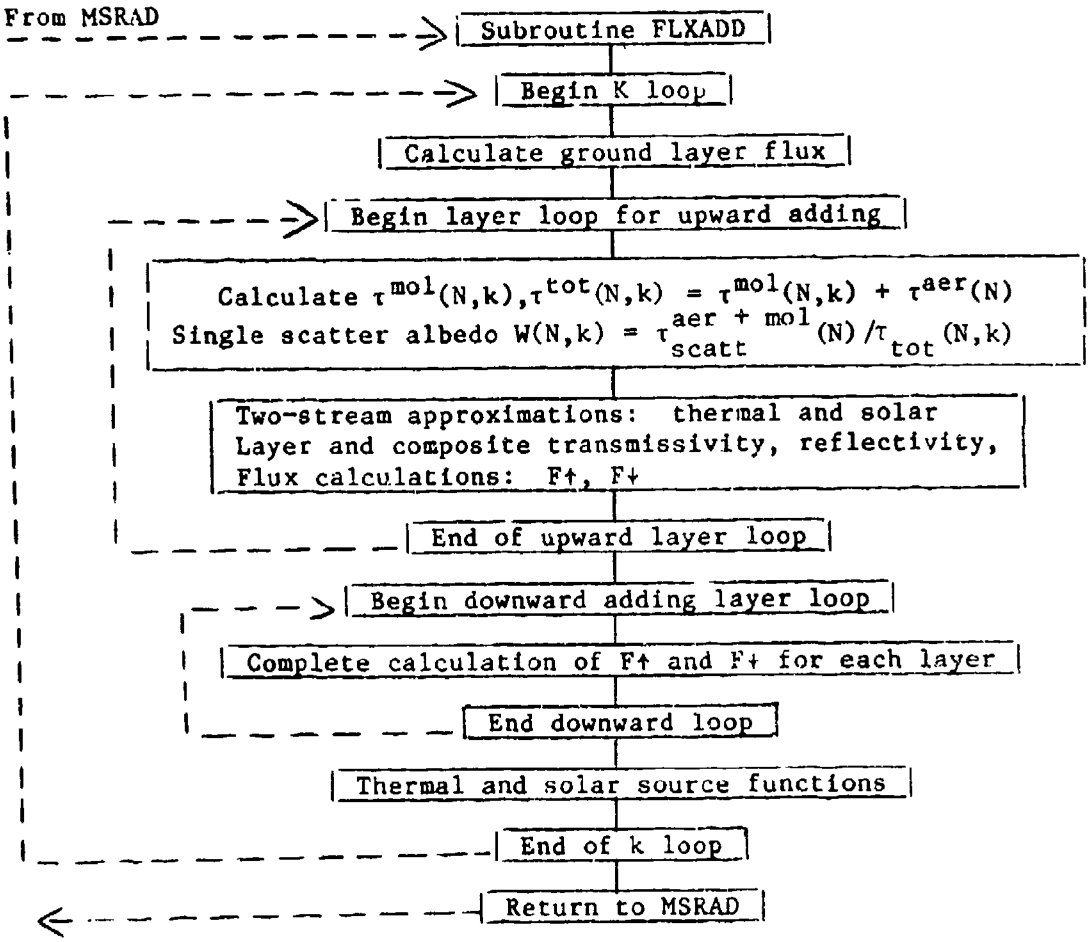


Figure 3-10. Flowchart of Subroutine FLXADD.

3.2.6 Notes on the Operation of LOWTRAN6 with Multiple Scattering

As previously discussed, the only change to the LOWTRAN input card images occurs in card 1 with the addition of the input parameter IMULT used to turn multiple scattering on or off. Card 1 is now read as follows:

MODEL,ITYPE,IEMSCT,M1,M2,M3,IM,NOPRNT,TBOUND,SALB,IMULT

I5 , I5 , I5 ,I5,I5,I5,I5, I5 ,F10.3 ,F10.3, I5

As previously mentioned, setting IMULT = 1 initiates multiple scattering, while IMULT = 0 provides single scattering or clear sky results.

Unlike the original LOWTRAN6, the new LOWTRAN6 requires a complete atmospheric profile (surface to space) to properly calculate the multiple scattering contribution to the radiance. For a calculation involving a path from 0-1 km, for example, it is still necessary to choose the desired stratospheric as well as higher level aerosol distribution set by IVULCN on card 2. For a 3-20 km path, the boundary layer aerosols, set using IHAZE, on card 2 or user-defined via card 2D, will now affect the calculated radiance. The original LOWTRAN performing single scattering required aerosol information only along the path between observer and target.

As currently set up, LOWTRAN6 will not do multiple Rayleigh scattering for IHAZE = 0 but will instead default to the original LOWTRAN6 single scattering calculation. To perform a multiple Rayleigh scattering calculation without boundary layer aerosols, choose IHAZE > 0 and set the visibility (VIS on card 3) to a large value such as 300 km to effectively eliminate the effect of these aerosols.

When LOWTRAN6 is run in its original form (single scattering only, IMULT = 0), the output for a solar case includes the reflected attenuated direct solar radiance under the heading GROUND REFLECTED. However, in many cases, the ground reflected diffuse radiance due to single and multiple scattering is of the same order of magnitude as the direct reflected radiance. The output for new LOWTRAN6 (IMULT = 1) has therefore been altered to include both the total (diffuse single and multiple scattered and direct) and direct reflection terms. Since the original single scatter LOWTRAN does not calculate downward radiance at the surface for an upward radiance case, the single scattered diffuse reflection term cannot currently be calculated.

Running LOWTRAN6 with multiple scattering results in a several-fold increase in CPU time. The atmospheric profile and path being used may not produce a significant multiple scattering contribution, possibly resulting in wasted computer time. A new feature has therefore been added to the solar output. Both the total (single and multiple) and single scattered radiance are now included under the heading "PATH SCATTERED RADIANCE." If in doubt, the user may now run a multiple scatter LOWTRAN run to determine the relative size(s) of the single and multiple scatter contributions. If multiple scattering is negligible, future calculations may be made with the more economical single scatter (IMULT = 0) option.

Test cases for LOWTRAN are provided in Appendix C.

4. RESULTS OF INTERCOMPARISON OF IMPLEMENTED MULTIPLE SCATTERING APPROACH WITH EXACT CALCULATIONS

4.1 Comparison of FASCODE Multiple Scattering Results to Exact Calculations

The detailed approach described in the previous sections was employed to develop a multiple scattering version of FASCODE based on the stream approximation and adding method. In order to verify the operation of the code, a number of test cases were run. To validate the results, these test cases were also run with the discrete ordinate code (DOM) for multiple scattering. Additionally, the existing nonscattering version of FASCODE was run for comparison. The optical properties for these test cases and corresponding radiance results are given in Table 4-1(a)-(c). Three test cases were selected. Case I is based on a FASCODE run at 900 cm-1 with a rural haze and 5 km visibility. This resulted in an optical depth of 0.357 and a single scattering albedo of 0.126. With this small albedo, the effects of scattering are expected to be small and results for all three methods should be comparable. In order to enhance the scattering effects and emphasize the differences between approaches, the number density of aerosol was increased to nonphysical amounts to yield single scattering albedos in the vicinity of 0.5 (case II) and 0.9 (case III). Note that the FASCODE models include the effect of atmospheric refraction while the discrete ordinate method code is strictly a plane parallel model. Comparisons of these results for zenith angles in the domain from 65 to 115 degrees should be made with this in mind.

Results are plotted in Figures 4-1 to 4-6. Upward and downward emergent radiances for Case I are shown in Figures 4-1 and 4-2, respectively. Here FASCODE, FASCODEMS, and the DOM are shown to give approximately the same magnitude and angular distribution of radiance. A slight tendency for FASCODE to underestimate the upward radiance and overestimate the downward radiance can be noted. At a higher optical depth and single scattering albedo (case II), this effect becomes obvious (Figures 4-3 and 4-4, respectively.) Here it can be seen that FASCODEMS does a clearly superior job at representing the angular radiance distribution. For a situation where multiple scattering dominates over gas absorption (case III, Figures 4-5 and 4-6), the deficiency of the absorption only FASCODE model is obvious.

Table 4-1

Scattering Comparisons for FASCODE Multiple Scattering Runs

(WAVELENGTH = 900 CM-1 , RADIANCES = ERG SEC-1 CM-2 (CM-1)-1 STR-1)

(a) CASE I. SMALL SCATTERING

TAU=0.357, OMEGA0=0.126, ASYMMETRY FACTOR=0.6985

ZENITH ANGLE (DEGREES)	AFGL FASCODE (NO MS)	AER FASCODE (MS)	DISCRETE ORDINATE METHOD (MS)
	UPWARD RADIANCES		
0.000	101.29	102.55	106.24 †
8.349	[illegible]	102.42	103.07
19.165	[illegible]	101.84	102.45
30.045	[illegible]	100.69	101.23
40.939	[illegible].29	98.75	99.18
51.839	94.02	95.58	95.81
62.741	88.62	90.23	90.09
73.644 *	79.17	80.66	79.61
84.548 *	68.23	68.29	60.96
	DOWNWARD RADIANCES		
95.452 *	65.16	63.44	68.51
106.356 *	46.79	44.37	46.72
117.259	35.15	32.85	34.09
128.161	28.48	26.36	27.12
139.061	24.43	22.48	23.01
149.955	21.92	20.11	20.49
160.835	20.41	18.70	19.00
171.651	19.64	17.98	18.24
180.000	19.47	17.81	14.69 †

†This point extrapolated in discrete ordinate method.
*FASCODE path is refracted while discrete ordinate method is plane parallel. These zenith angles are affected.

(2) CASE II. INTERMEDIATE SCATTERING

TAU=0.555, OMEGA0=0.498, ASYMMETRY FACTOR=0.6985

ZENITH ANGLE (DEGREES)	AFGL FASCODE (NO MS)	AER FASCODE (MS)	DISCRETE ORDINATE METHOD (MS)
		UPWARD RADIANCES	
0.000	94.73	101.62	103.52 †
8.349	94.55	101.48	101.43
19.165	93.77	100.85	100.69
30.045	92.25	99.63	99.21
40.939	89.79	97.53	96.68
51.839	86.00	94.02	92.50
62.741	80.24	88.21	85.45
73.644 *	71.93	78.66	73.33
84.548 *	68.01	68.06	55.37
		DOWNWARD RADIANCES	
95.452 *	66.48	59.53	70.14
106.356 *	56.04	44.76	50.95
117.259	45.63	34.02	37.25
128.161	38.49	27.40	29.14
139.061	33.78	23.35	24.28
149.955	30.72	20.89	21.32
160.835	28.84	19.46	19.58
171.651	27.87	18.71	18.70
180.000	27.65	18.55	16.80 †

(c) CASE III. LARGE SCATTERING

TAU=0.308, OMEGAO=0.897, ASYMMETRY FACTOR=0.6985

ZENITH ANGLE (DEGREES)	AFGL FASCODE (NO MS)	AER FASCODE (MS)	DISCRETE ORDINATE METHOD (MS)
		UPWARD RADIANCES	
0.000	103.31	112.24	119.78 †
8.349	102.97	112.19	113.19
19.165	102.46	111.96	112.81
30.045	101.46	111.49	112.03
40.939	99.78	110.53	110.58
51.839	97.01	108.57	107.87
62.741	92.28	104.51	102.49
73.644 *	83.37	95.13	90.55
84.548 *	68.85	68.79	62.28
		DOWNWARD RADIANCES	
95.452 *	63.04	46.54	57.61
106.356 *	41.52	21.81	28.65
117.259	30.60	12.71	16.29
128.161	24.75	8.72	10.68
139.061	21.33	6.78	7.84
149.955	19.24	5.83	6.31
160.835	18.00	5.37	5.48
171.651	17.37	5.14	5.09
180.000	17.23	5.09	---- †

In order to gain some insight into the differences between the FASCODE and FASCODEMS results, a radiance budget has been computed for one upward and one downward zenith angle corresponding to case II. These radiance budgets are presented in Table 4-2 and provide the magnitude of contributions to the total radiance from surface emission, atmospheric emission, and the scattering source function, as applicable. Radiance values are rounded for simplicity.

Table 4-2

Case II Radiance Budgets [unattenuated surface emission corresponds to 120 radiance units; units = erg s^{-1} cm^{-2} str^{-1} $(cm^{-1})^{-1}$].

	FASCODE	FASCODEMS	DOM
(a) Upward Radiance (zenith angle 8.3 degrees)			
Surface emission	65	65	
Atmospheric emission	30	16	
Scattering source		20	
Total	95	101	101
(b) Downward Radiance (zenith angle 171.7 degrees)			
Atmospheric emission	28	12	
Scattering source	-	8	
Total	28	20	19

Examination of Table 4-2 indicates that FASCODE over estimates atmospheric emission in the presence of scatterers since it assumes that scattering extinction is equivalent to absorption. In this case radiation absorbed is re-emitted. While scatterers may absorb and re-emit, some fraction of the extinction due to their presence (i.e., that given by their single scattering albedo) is simply redirected. In the case of the upward intensity in Table 4-2, forward scattering of some of the surface emission lost due to extinction more than compensates for the decreased atmospheric emission. Thus the non-scattering version of FASCODE underestimates the radiance. For the downward radiance in Table 4-2, the small scattering source does not compensate for the decrease in atmospheric emision due to the treatment of scattering. In this case FASCODE overestimates the actual radiance.

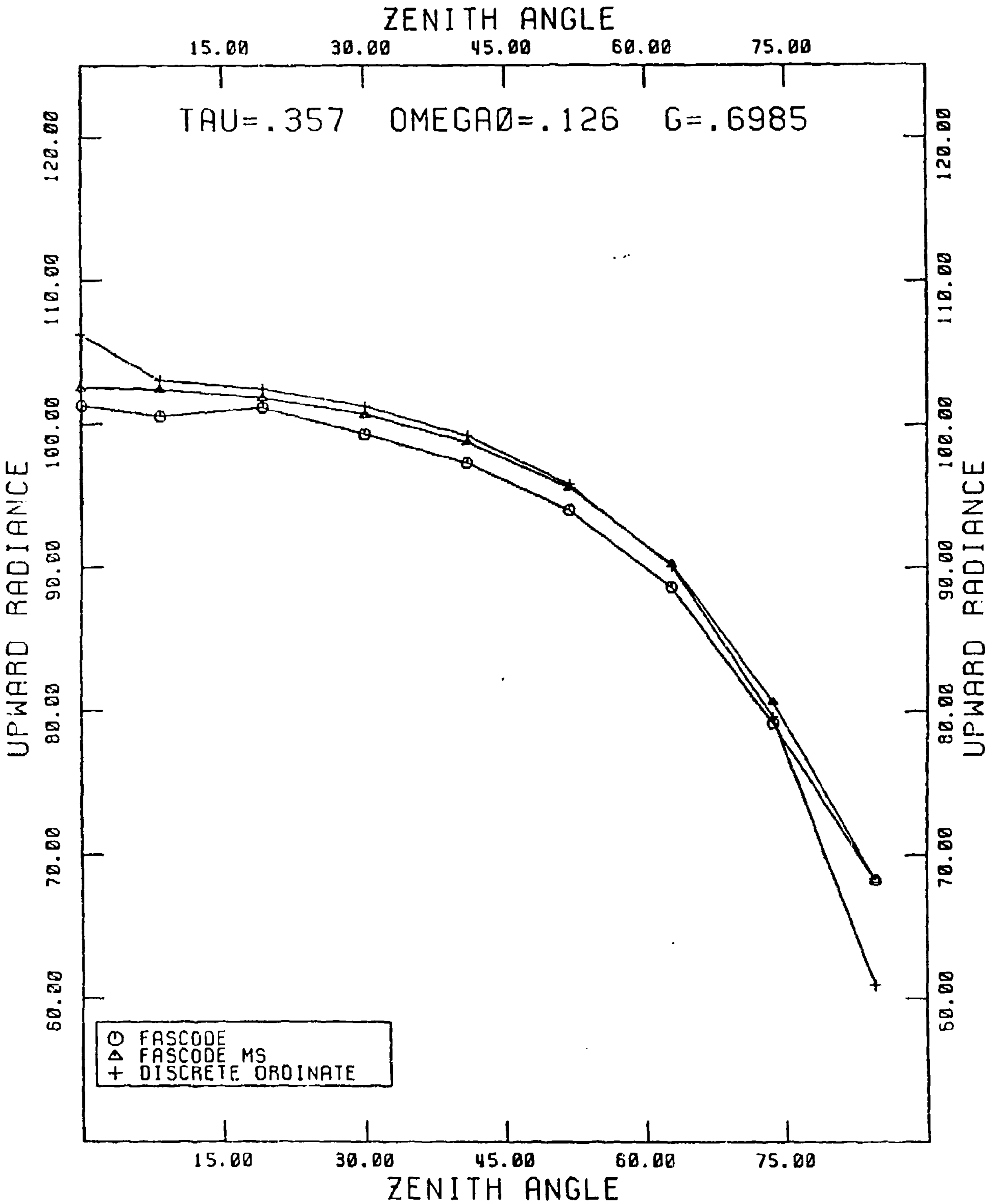


Figure 4-1. Comparison of FASCODE, FASCODEMS, and DOM for upward radiance [units: ergs sec^{-1} cm^{-2} str^{-1} $(cm^{-1})^{-1}$]

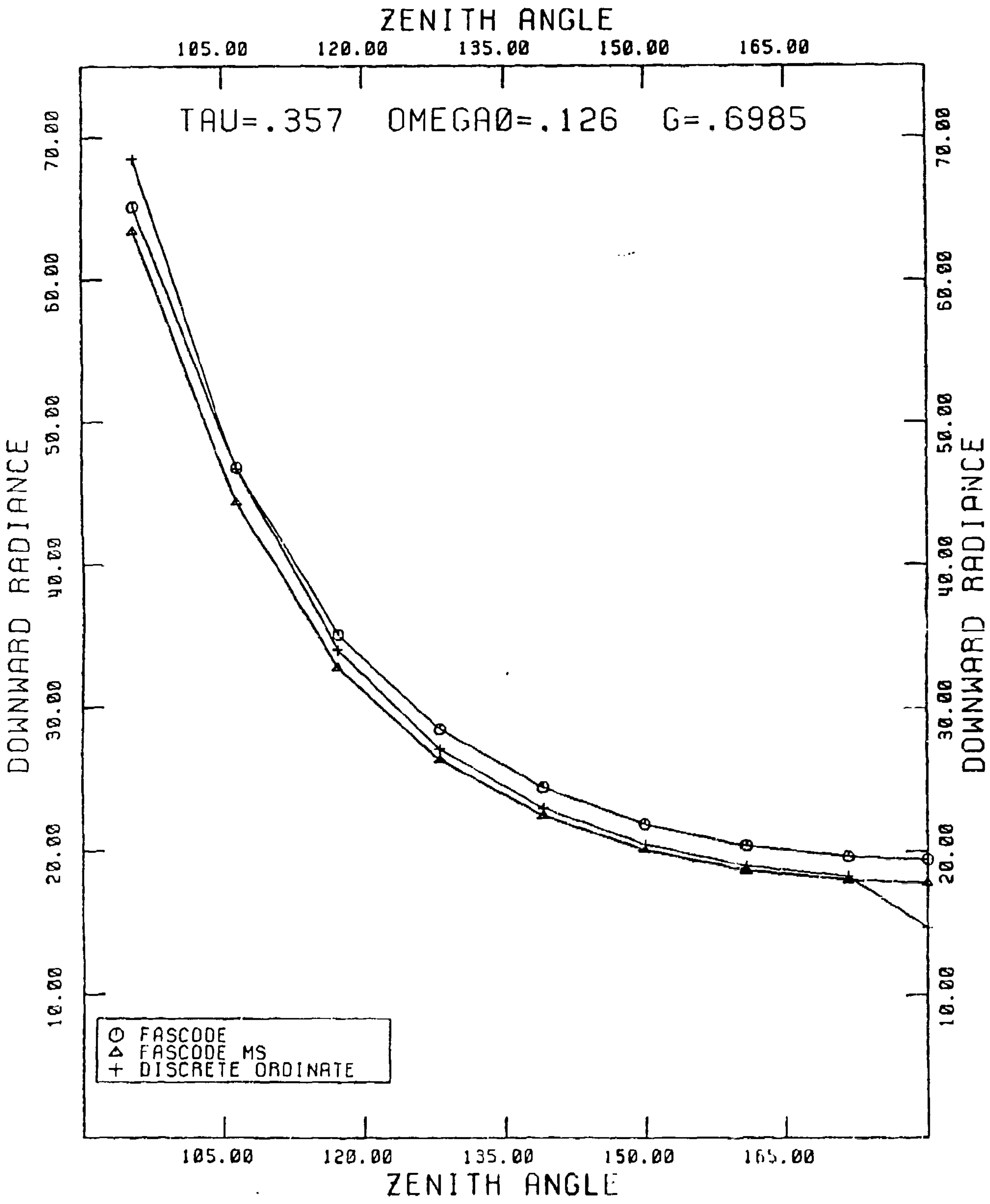


Figure 4-2. Comparison for FASCODE, FASCODEMS, and DOM for downward radiance [units: ergs sec^{-1} cm^{-2} str^{-1} $(cm^{-1})^{-1}$]

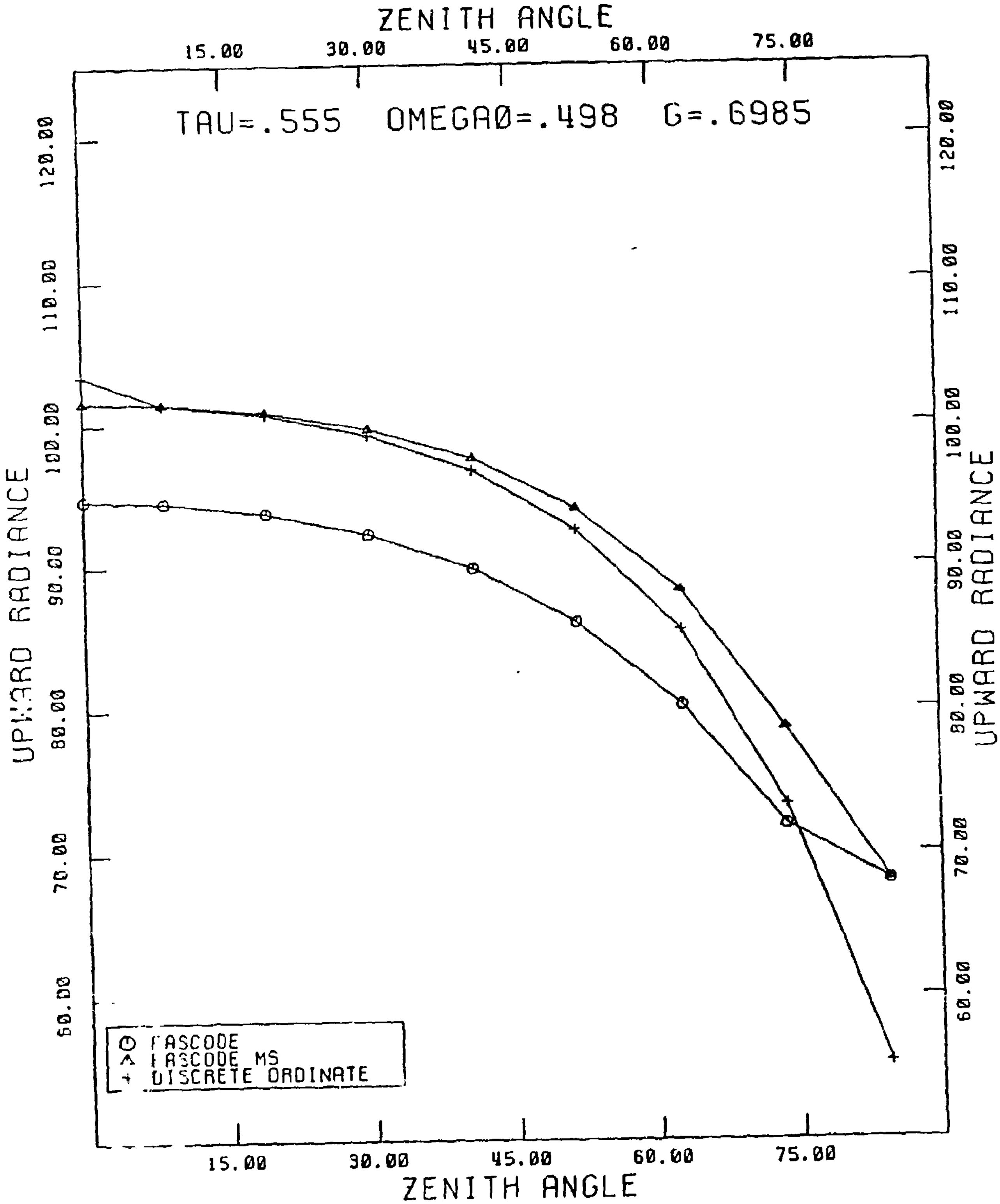


Figure 4-3. Comparison of FASCODE, FASCODEMS, and DOM for upward radiance [units: ergs sec^{-1} cm^{-2} str^{-1} $(cm^{-1})^{-1}$]

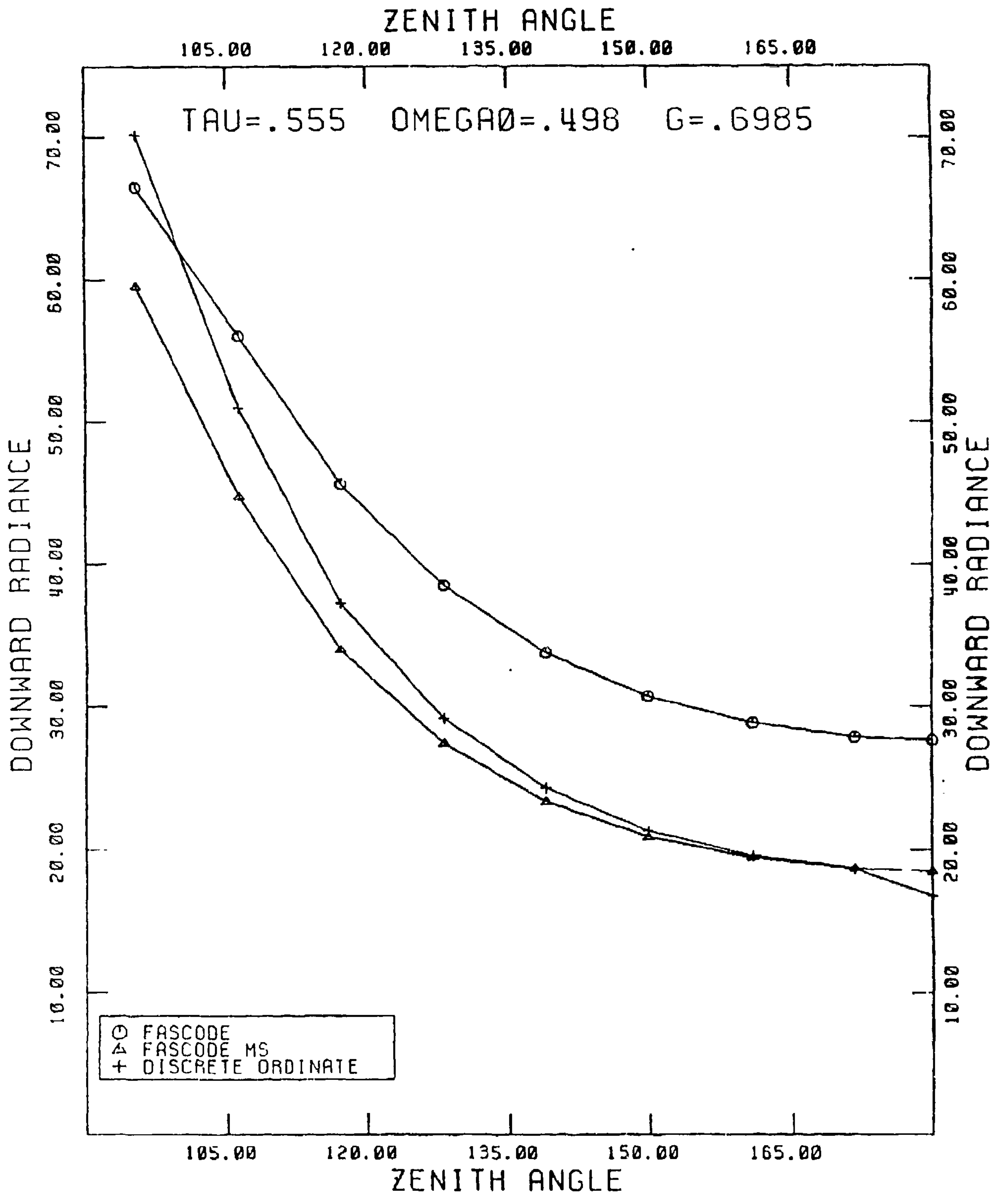


Figure 4-4. Comparison for FASCODE, FASCODEMS, and DOM for downward radiance [units: ergs sec^{-1} cm^{-2} str^{-1} $(cm^{-1})^{-1}$]

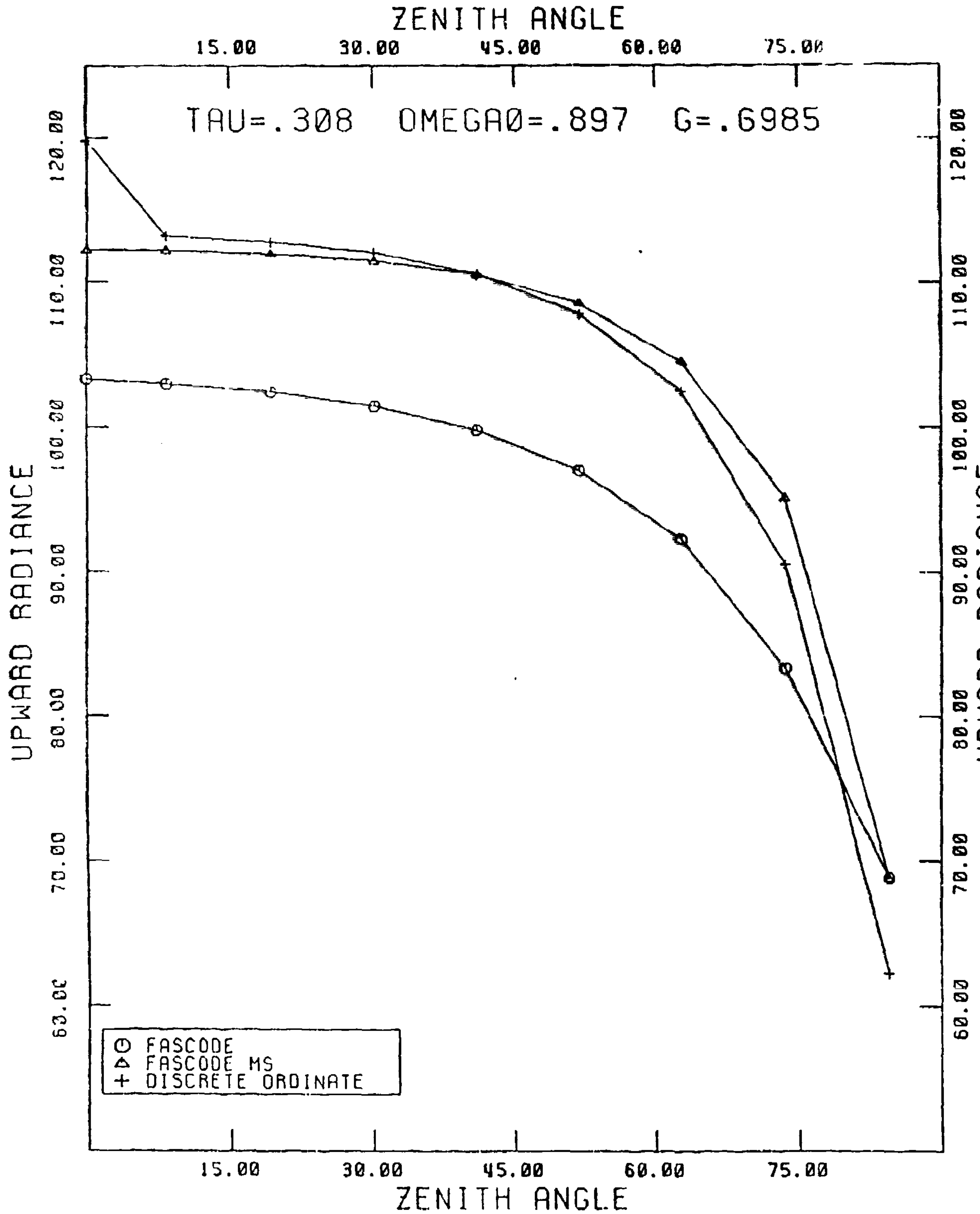


Figure 4-5. Comparison of FASCODE, FASCODEMS, and DOM for upward radiance [units: ergs sec^{-1} cm^{-2} str^{-1} $(cm^{-1})^{-1}$]

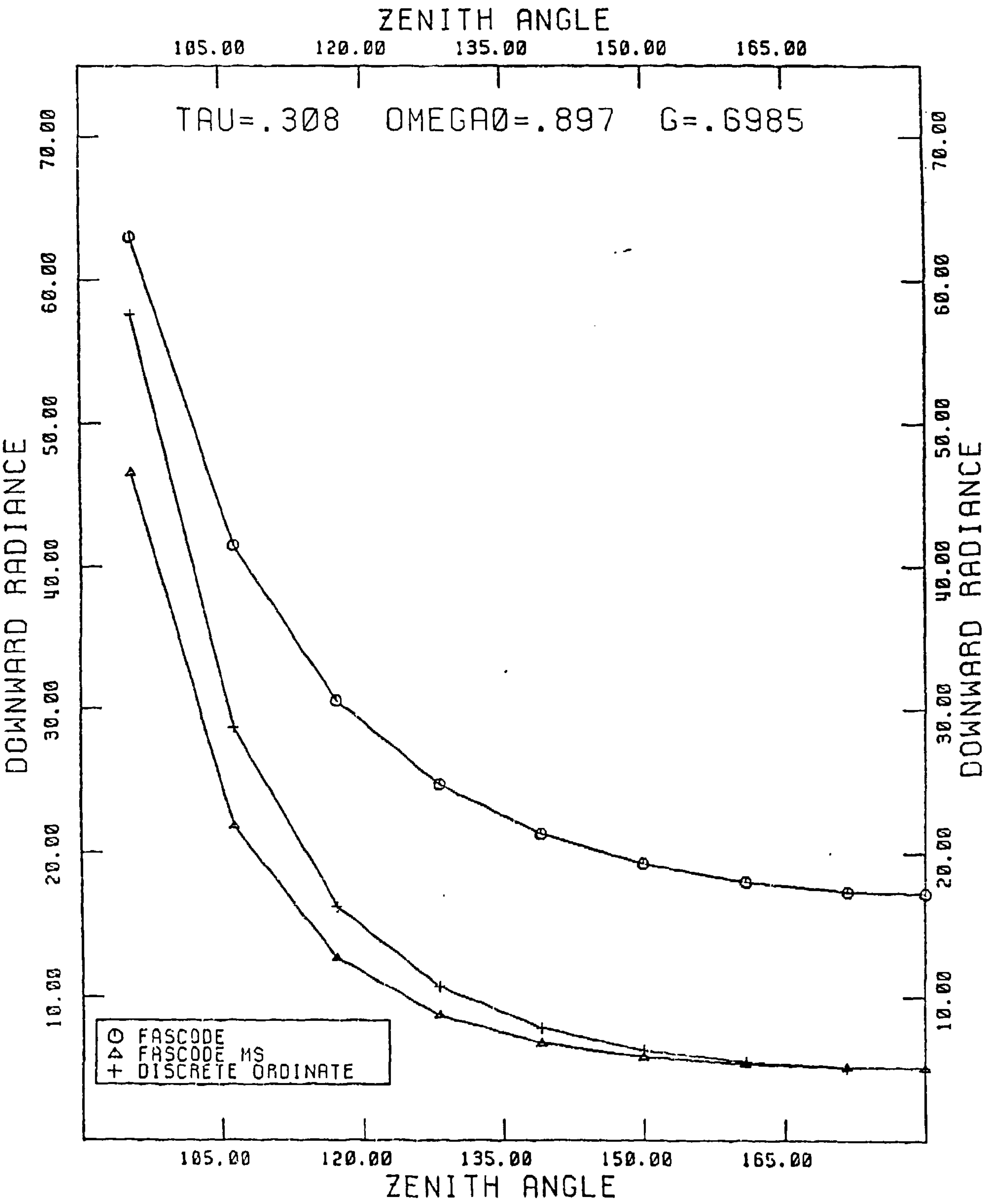


Figure .-6. Comparison for FASCODE, FASCODEMS, and DOM for downward radiance [units: ergs sec^{-1} cm^{-2} str^{-1} $(cm^{-1})^{-1}$]

4.2 Comparison of LOWTRAN Multiple Scattering Results to Exact Calculations

4.2.1 Solar Multiple Scattering

In order to verify the correct operation of the implemented LOWTRAN multiple scattering treatment for both solar and thermal regimes, comparisons were made to exact results.

In the case of solar multiple scattering, exact results were obtained for a variety of cases during the trade-off analysis summarized in Appendix A. Exact solutions to the radiative transfer equation for solar multiple scattering were obtained using the Gauss-Seidel iterative method based on a code by Dave (1972). This algorithm evaluates the fluxes and radiances for inhomogeneous atmospheres with arbitrary vertical distributions of anisotropically scattering aerosol overlying a Lambert reflecting surface. Emergent fluxes and radiances from this code were compared to those obtained from LOWTRAN for three values of total optical thickness (0.25, 0.50, 1.00) and two values of surface albedo (0.0, 0.4).

A number of special modifications of LOWTRAN were necessary to accommodate the comparison. These included reading in the same aerosol extinction and absorption coefficients, asymmetry factor, and phase function as were used for the Dave model runs, and forcing LOWTRAN to use the quantities with the same vertical distribution as the Dave code. (Ordinarily, user supplied aerosol data read into LOWTRAN will only be used in the lowest 2 km of the atmosphere.) These changes made the comparison as close as possible to a direct one. The LOWTRAN code was run at 0.55 μm with the sun at a zenith angle of 60°.

The first test of the LOWTRAN implementation is whether the adding method is calculating the correct fluxes for use in the stream approximation of the multiply scattered source function. Table 4.3 compares the emergent fluxes calculated by the exact code and LOWTRAN. For simplicity all fluxes and radiances plotted here have been normalized to correspond to π units of incident solar irradiance. To obtain the appropriate engineering units (watts/cm^2 cm^{-1}, and watts/cm^2 str cm^{-1}, for flux and radiance, respectively), the normalized values can be multiplied by 1.719×10^{-6}. As can be seen from the results, the solar two stream approximation and flux adding procedure in LOWTRAN is reproducing the exact values quite well throughout the range of

optical thicknesses and surface albedos examined. The errors, on the order of a few percent, are to be expected from the two stream approximation.

Figures 4-9 through 4-12 illustrate the comparison between the exact radiance calculation as a function of path zenith angle (theta) and those obtained from LOWTRAN using either the solar single scattering option (LOWTRAN) or the new multiple scattering option (LOWTRAN MS). Plotted are the normalized emergent upward and downward radiances for an optical depth of 0.5 and surface albedos of 0.0 and 0.4. The plots extend to a maximum zenith angle of 60° since at larger angles the effects of refraction in the LOWTRAN code make it difficult to compare to the plane parallel exact results. In all cases it can be seen that the introduction of the multiply scattered contribution to path radiance in LOWTRAN MS has considerably improved the simulation as compared to that obtained from the exact code. The improvement is considerable, especially for upward radiance when there is surface reflection (see Figure 4-11). This is because although the single scatter version of LOWTRAN included the surface reflection of the attenuated direct solar beam, it contained no provision to treat the reflected downward scattered radiance. This contribution (which is the second term in the brackets in Equation (2.10)) may be considerable when multiple scattering is a factor and is included in the LOWTRAN MS version since the downward scattered flux is calculated as a result of the adding method.

The relative accuracies as a funtion of path zenith angle expressed as percent errors obtained in the comparisan between LOWTRAN MS and the exact calculations for all optical depths evaluated are summarized in Figures 4-13 and 4-14, for surface albedos of 0.0 and 0.4, respectively. In general, the solar multiple scattering approach implemented within LOWTRAN underestimates radiance by 10 or 20 percent. These accuracies are consistent with those obtained off line in the trade-off analysis (see Appendix A, Table A-5.)

4.2.2 Thermal Multiple Scattering

Proper operation of the code for thermal multiple scattering was verified by comparing LOWTRAN MS to corresponding FASCODE MS results. FASCODE MS has been compared to exact multiple scattering using the discrete ordinate method in Section 4.1. The case chosen was a vertical path from the surface to 20 km using a U.S. Standard atmosphere (MODEL 6) and a rural aerosol model

with 5 km visual range (IHAZE 2). The spectral domain for both runs was 850-1150 cm^{-1}. Figures 4-15a, b illustrate this comparison for upward and downward radiance, respectively. The FASCODE MS results have been degraded to 5 cm^{-1} for consistency with the LOWTRAN MS values. In general both models agree quite well within this spectral region. The slight discrepancy between degraded FASCODE and LOWTRAN spectra (especially for downward radiance) in this region is not due to multiple scattering effects, but rather to differences in the corresponding clear air spectra. This is illustrated by Figure 4-16 where all aerosols have been removed from the calculation.

One problem with the previous treatment of thermal scattering within LOWTRAN was the failure to provide a source function to introduce multiply scattered radiance contributions along the observed path. As a consequence of this ad hoc approach, LOWTRAN seriously underestimated path radiance for long paths such as those near the horizon where multiple scattering could contribute significantly (Ben-Shalom et al., 19 This deficiency is corrected with the implementation of the multiple scattering approach descibed here. To illustrate, radiances have been simulated for a ground based observer scanning the sky between 8.0 and 13.5 μm. Figures 4-17,4-18, and 4-19 illustrate the calculated results, for observing zenith, 10° above the horizon, and the horizon, using the standard LOWTRAN, the Ben-Shalom modification (Ben-Shalom et al, 1980), and LOWTRAN MS. For comparison, the black body function of the lowest atmospheric layer is also plotted. The calculation has assumed a mid-latitude summer atmosphere and 5 km visual range.

As can be seen in Figure 4-17, there is very little difference in the results among the three approaches when observing zenith when multiple scattering effects are minimized. For larger air mass factors, however, the three approaches diverge, with the LOWTRAN MS result bounded below by the standard LOWTRAN and above by the Ben-Shalom modified version (see Figure 4-18). This is understandable since standard LOWTRAN removes all scattered radiance from the path radiance and the Ben-Shalom modification assumes that all scattered radiance is returned to the path radiance (i.e., the scattering is conservative). Actually some of the scattered radiance is returned to the path radiance through the scattering source function. The fraction returned depends on the single scattering albedo and through the scattering phase function, on the viewing geometry. At the horizon (Figure 4-19), the standard LOWTRAN result

significantly underestimates the radiance level expected qualitatively, i.e., that approximating the emission of the lowest atmospheric layer.

In Figure 4-20a are plotted LOWTRAN MS results for the case described above with the observer path at various elevation angles. For comparison, Figure 4-20b reproduces a set of radiance measurements taken with qualitatively similar conditions (Bell et al,1960). Note that the wavelength range of these measurements is much broader than that illustrated in Figure 4-20a and the vertical scales are different. Additionally, the ambient temperature when the measurements were taken is about 5 K higher than that of the surface layer of the midlatitude summer model used in the LOWTRAN MS simulation. In spite of these differences, the simulated and measured radiances exhibit similar magnitudes and dependence on path elevation angle.

Table 4-3

Comparison of solar multiply scattered emergent fluxes (normalized to π units of incident irradiance) from LOWTRAN FLXADD subroutine (L) and exact calculation (E).

	Upward Flux F^{+} ($\tau = 0$)		Downward Flux F^{-} ($\tau = \tau^{*}$)	
τ^{*}	r = 0.0 L / E	r = 0.4 L / E	r = 0.0 L / E	r = 0.4 L / E
0.25	.188 / .191	.611 / .634	.323 / .316	.367 / .371
0.50	.244 / .256	.562 / .584	.503 / .489	.536 / .544
1.00	.316 / .324	.492 / .515	.599 / .567	.605 / .615

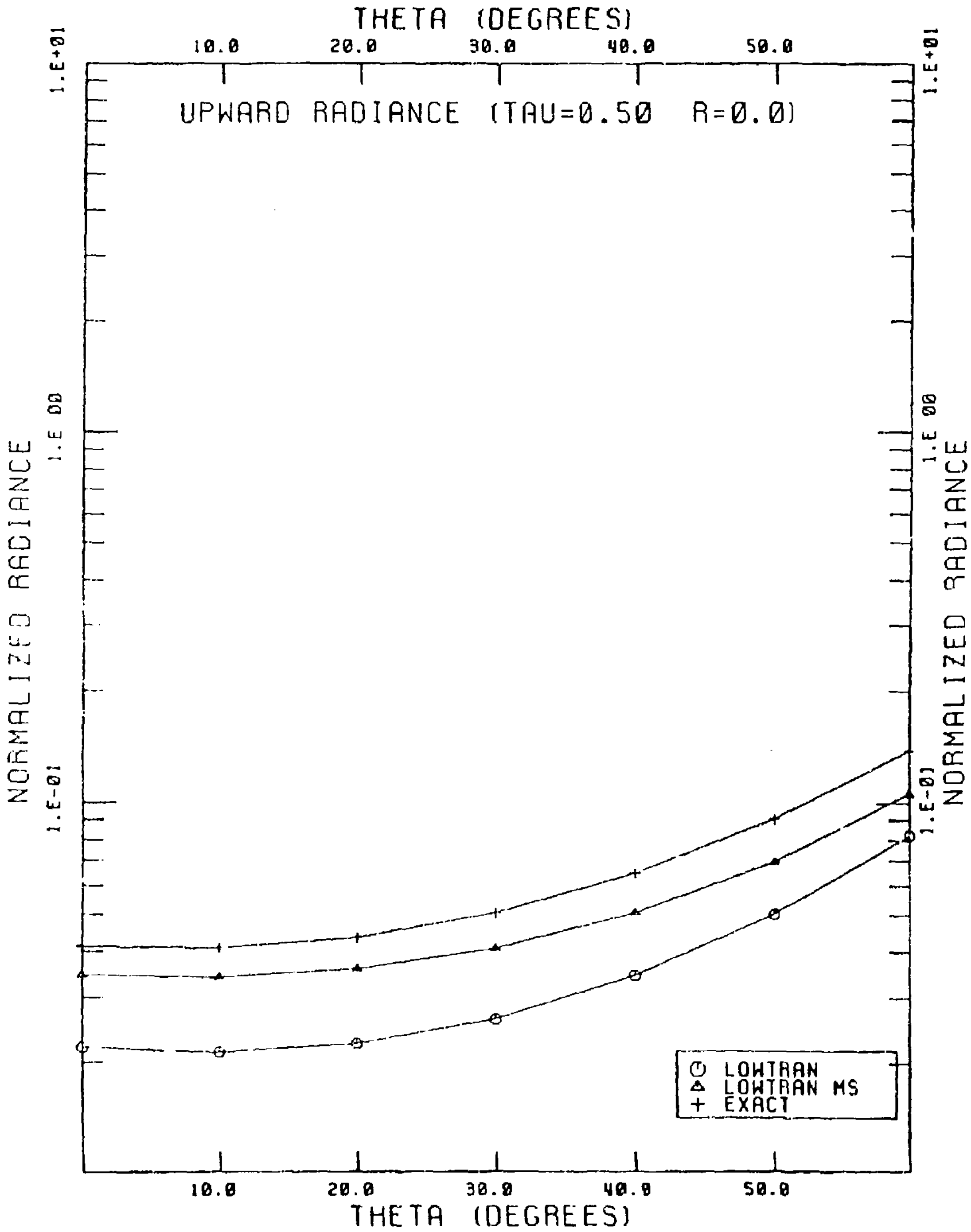


Figure 4-9. LOWTRAN6 upward radiance (solar, .55 μm) with and without multiple scattering comapred to exact (Dave) results. Solar zenity angle is 60°.

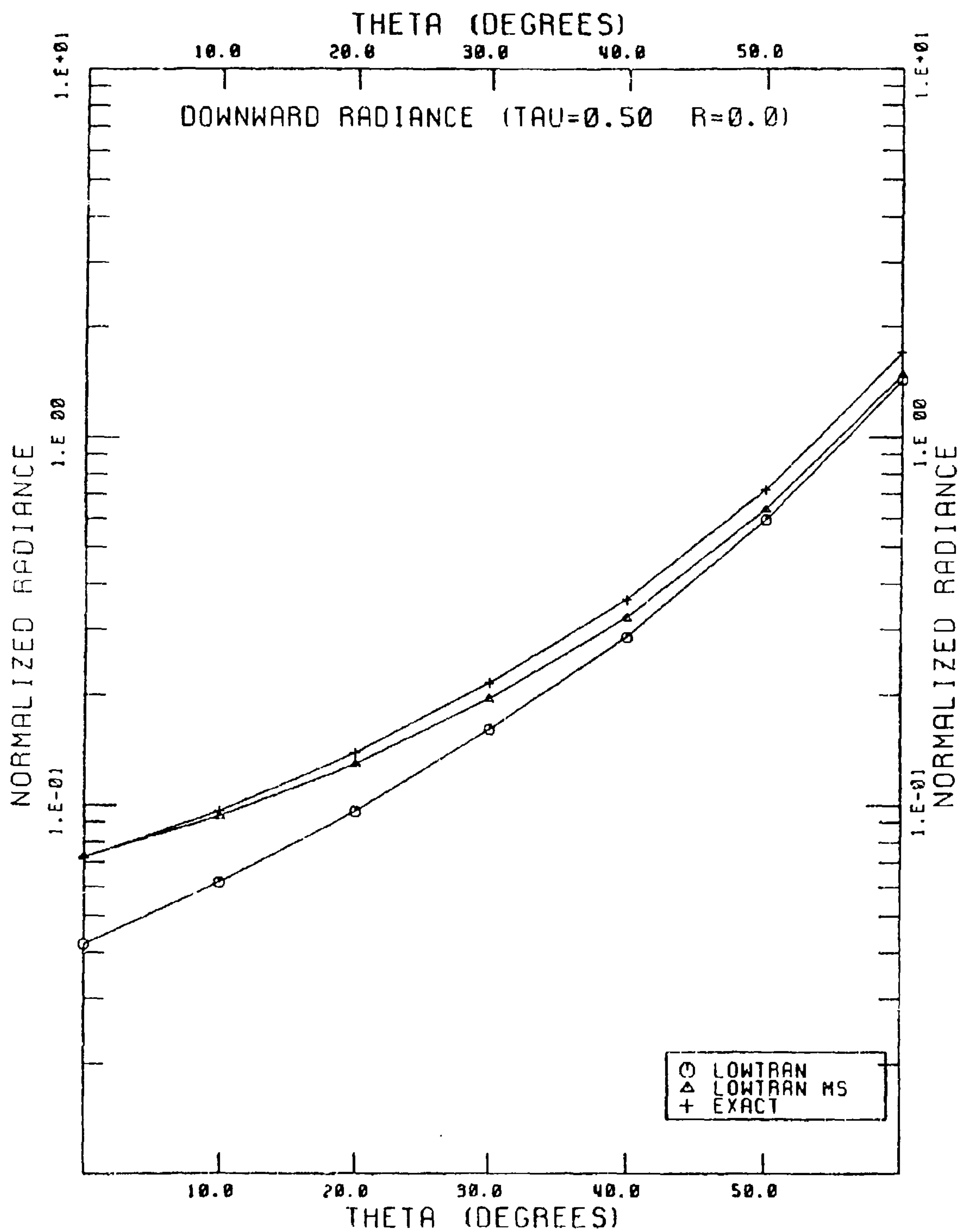


Figure 4-10. LOWTRAN6 downward radiance (solar, .55 μm) with and without multiple scattering compared to exact (Dave) results. Solar zenith angle is 60°.

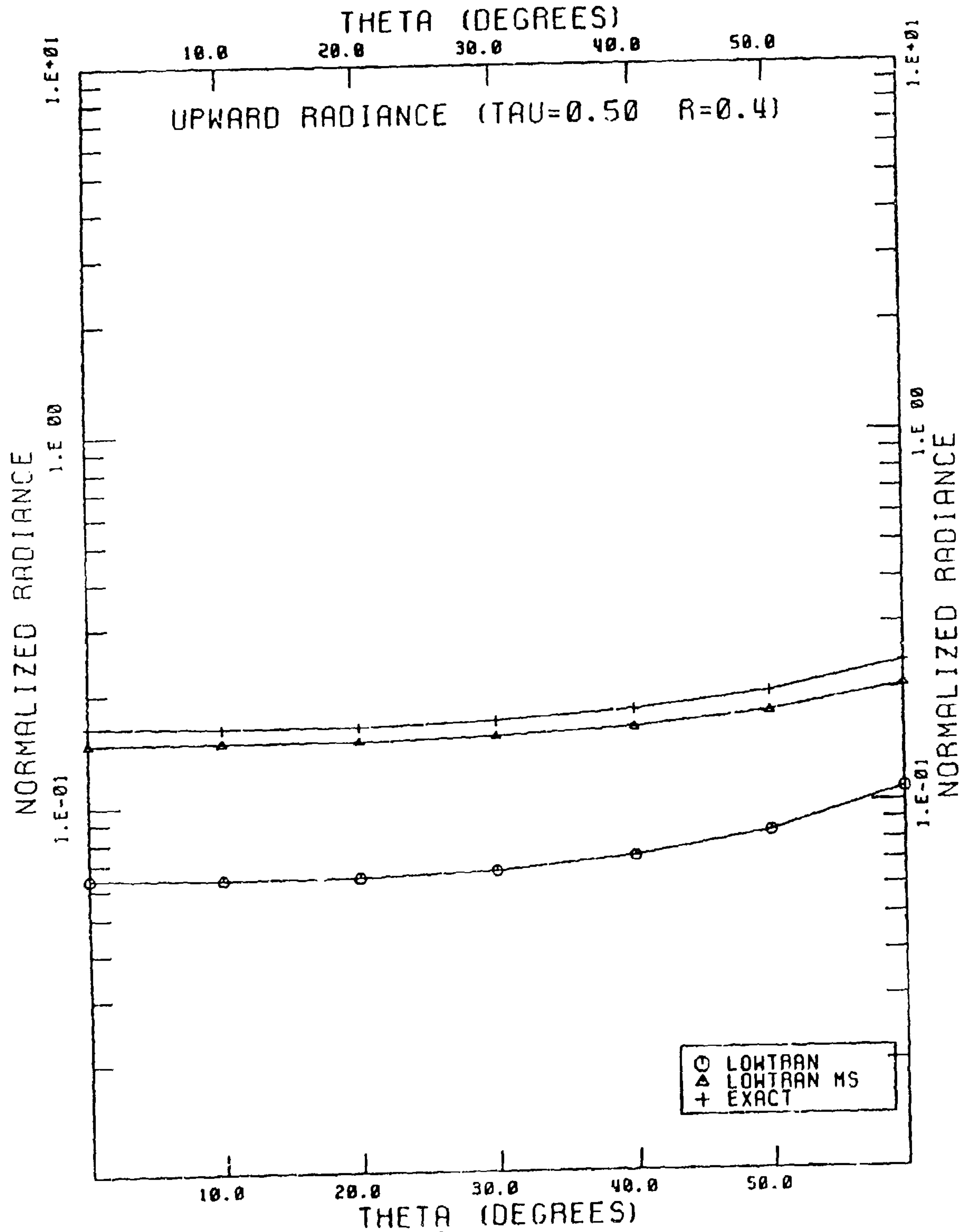


Figure 4-11. LOWTRAN6 upward ra ance (solar, .55 μm) with and without multiple scattering co pared to exact (Dave) results. Solar zenity angle is 60°.

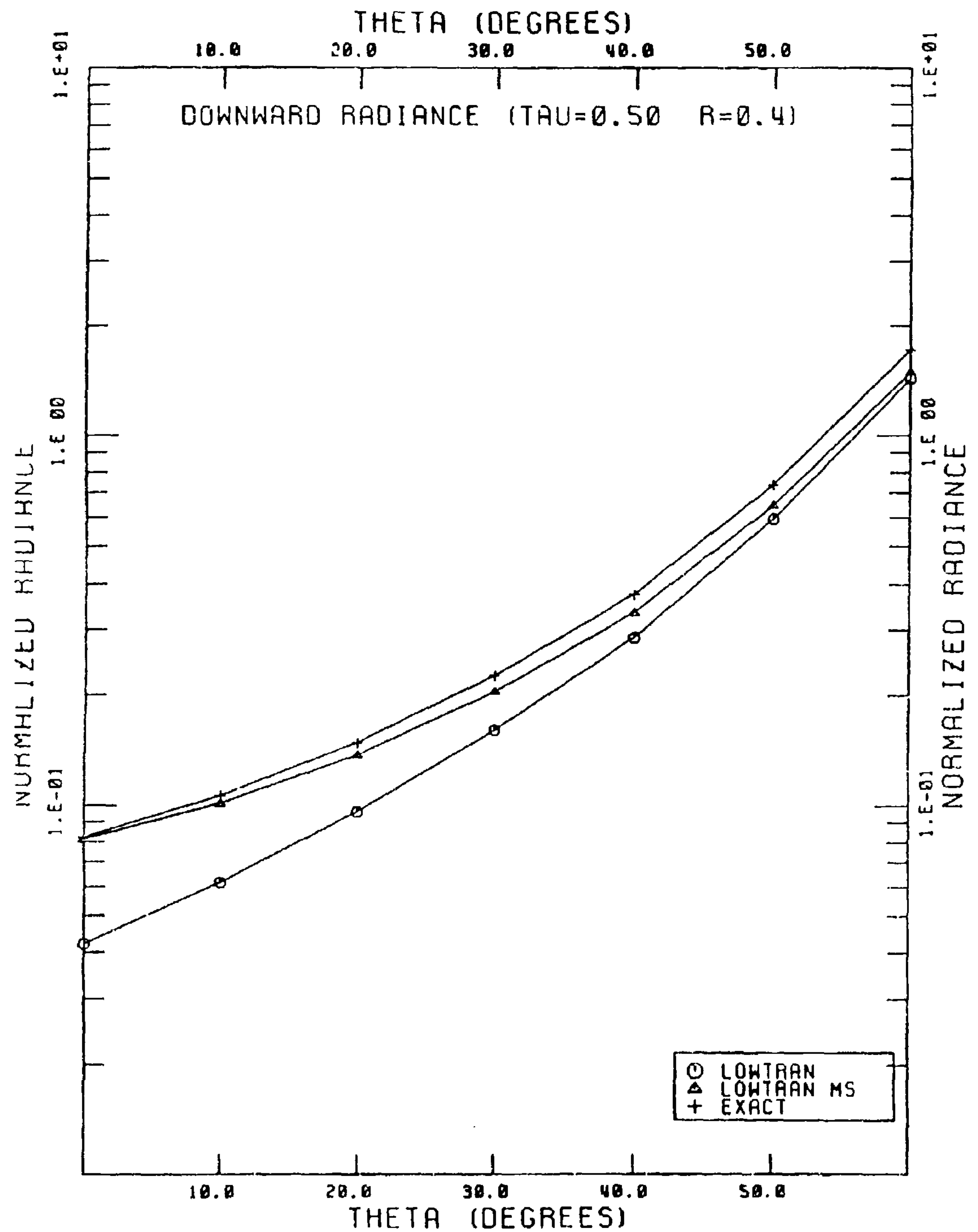


Figure 4-12. LOWTRAN6 downward radiance (solar, .55 μm) with and without multiple scattering compared to exact (Dave) results. Solar zenith angle is 60°.

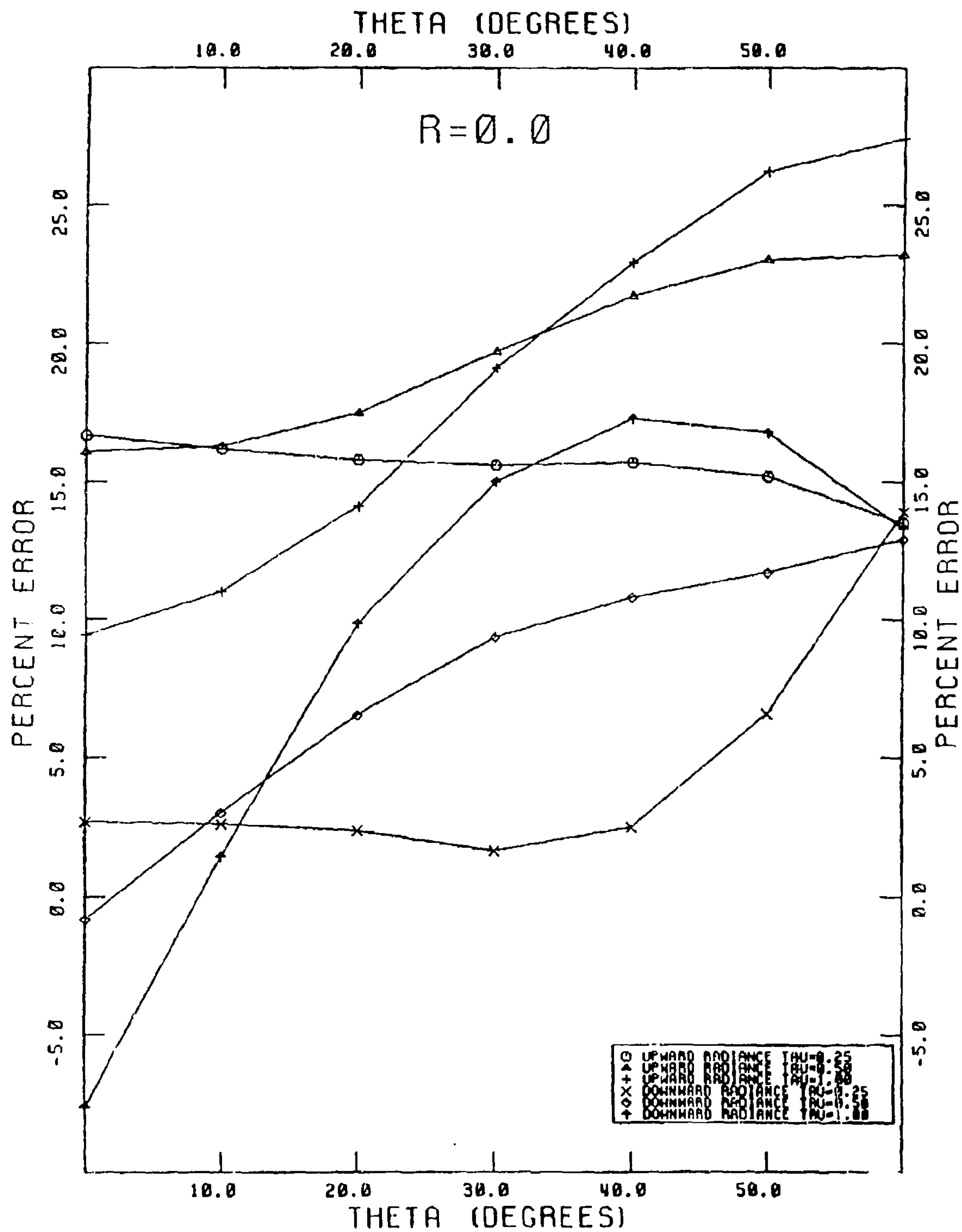


Figure 4-13. Percent error of LOWTRAN6 multiple scatter calculations relative to exact (Dave) results for optical depths between 0.25 and 1.00 with a surface reflectance of 0.0.

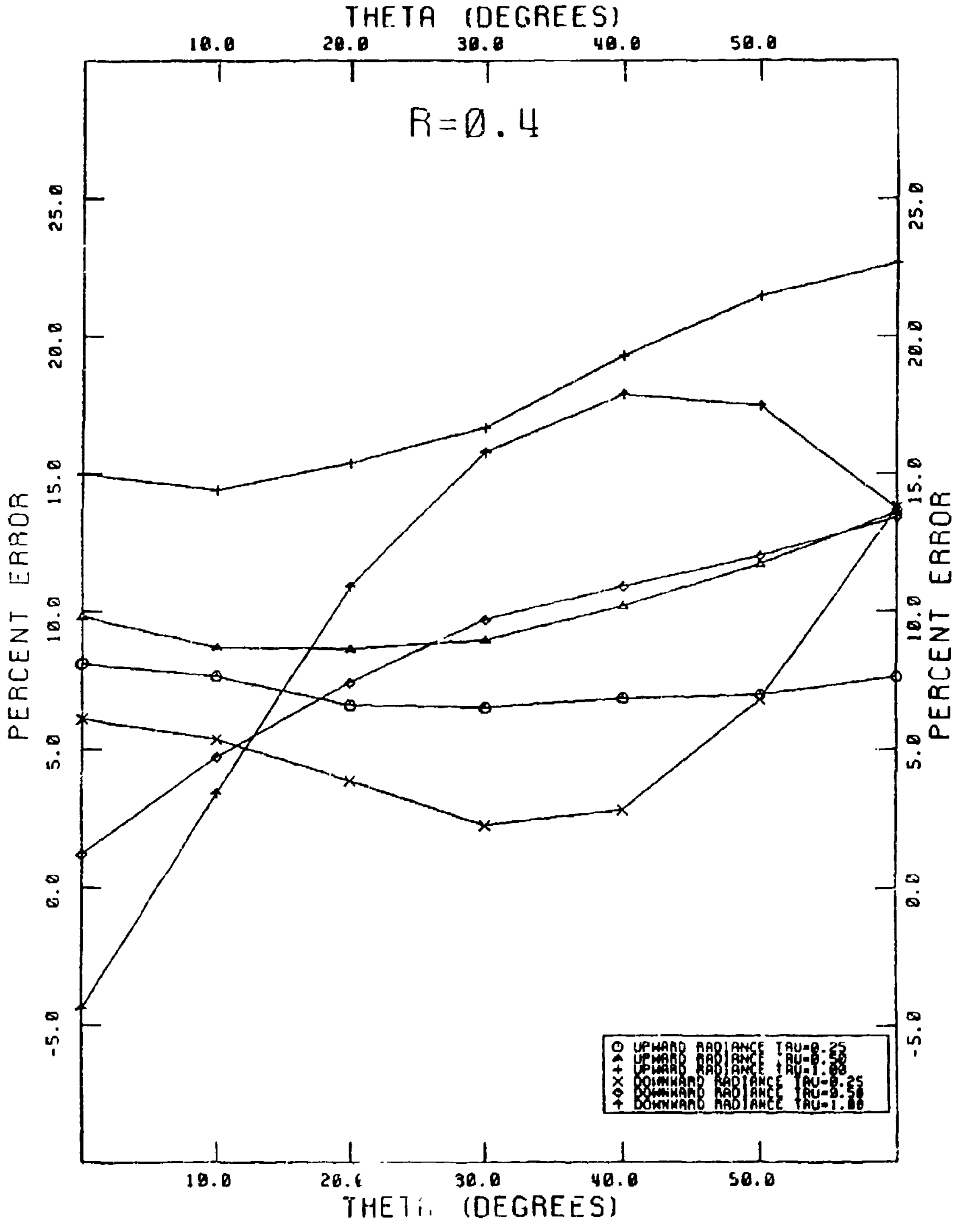


Figure 4-14. Percent error of LOWTRAN6 multiple scatter calculations relative to exact (Dave) results for optical depths between 0.25 and 1.00 with a surface reflectance of 0.4.

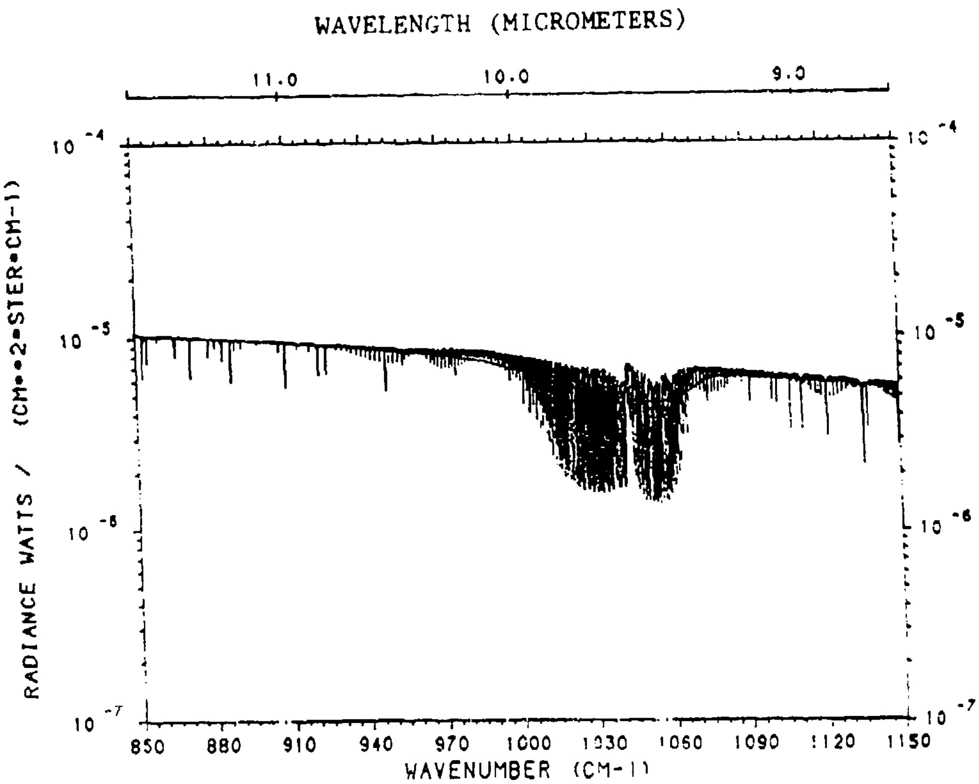


Figure 4-15a. Comparisons of LOWTRAN and FASCODE upward thermal radiance (with multiple scattering) between 850 and 1150 cm^{-1}.

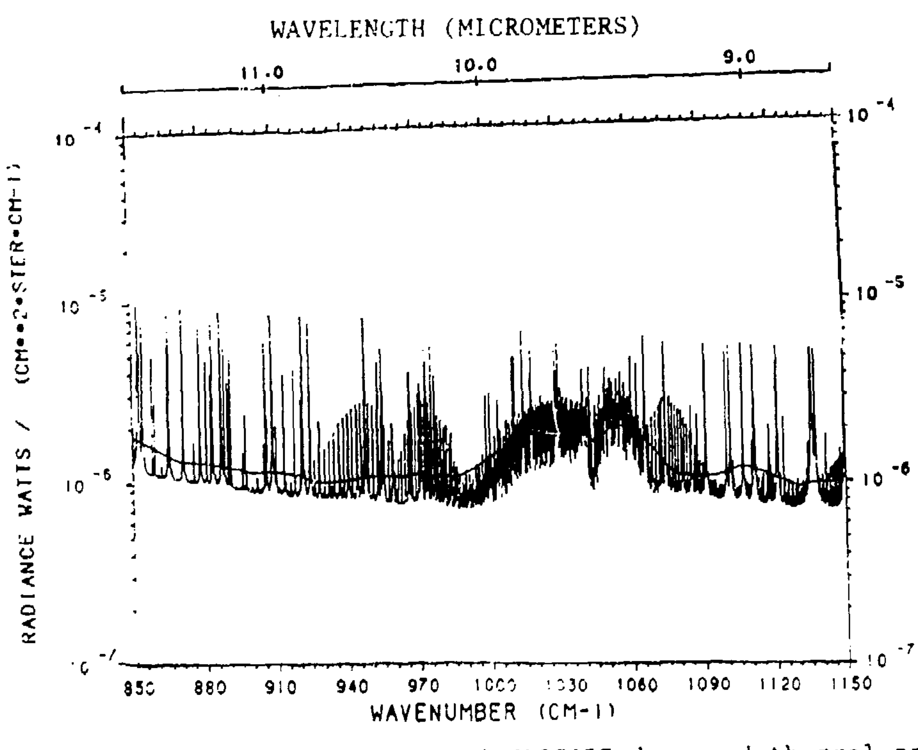


Figure 4-15b. Comparison of LOWTRAN and FASCODE downward thermal radiance (with multiple scattering) between 850 and 1150 cm^{-1}.

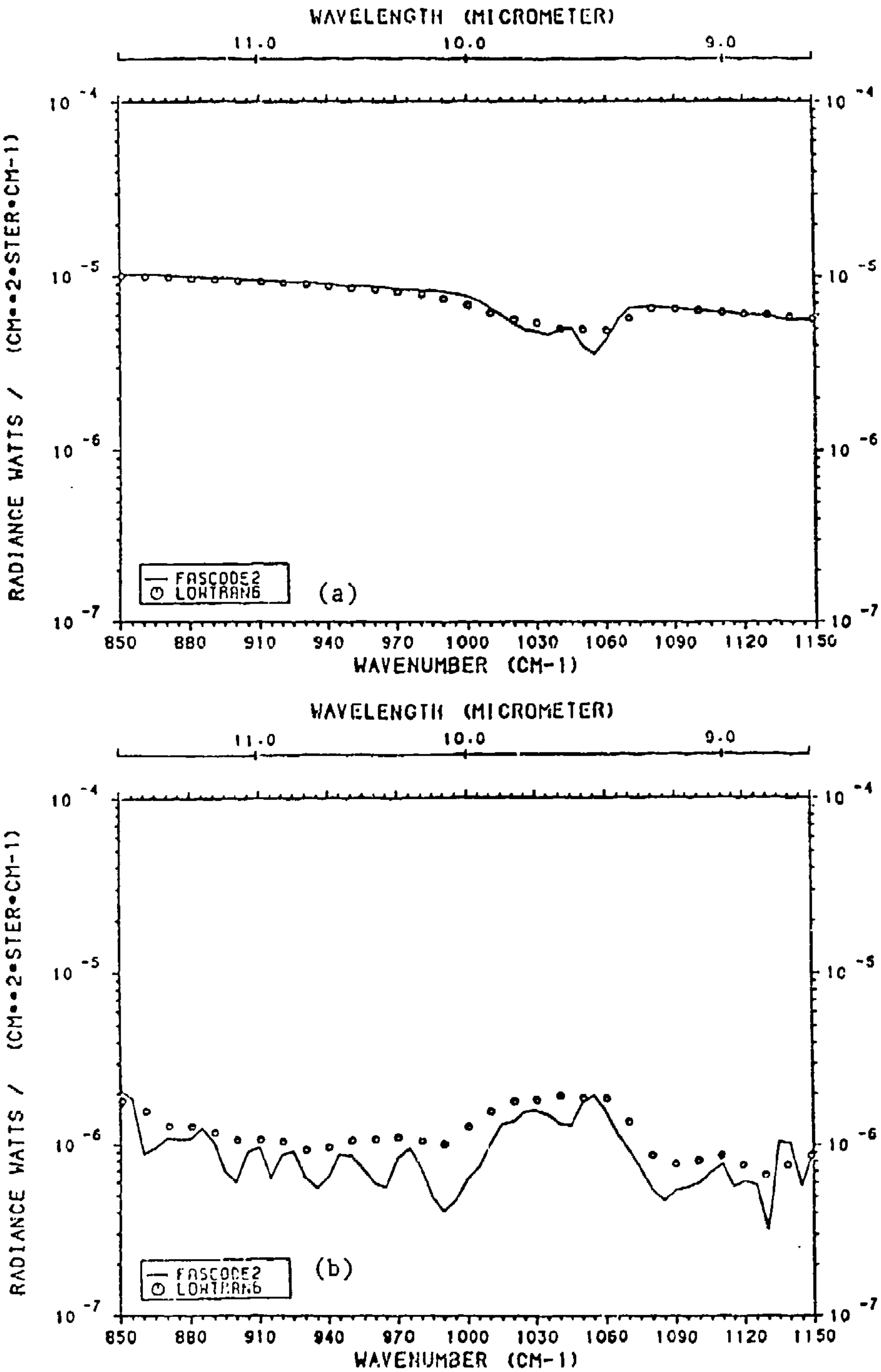


Figure 4.16. Comparisons of clear sky upward (a) and downward (b) radiances between LOWTRAN6 and FASCODE2.

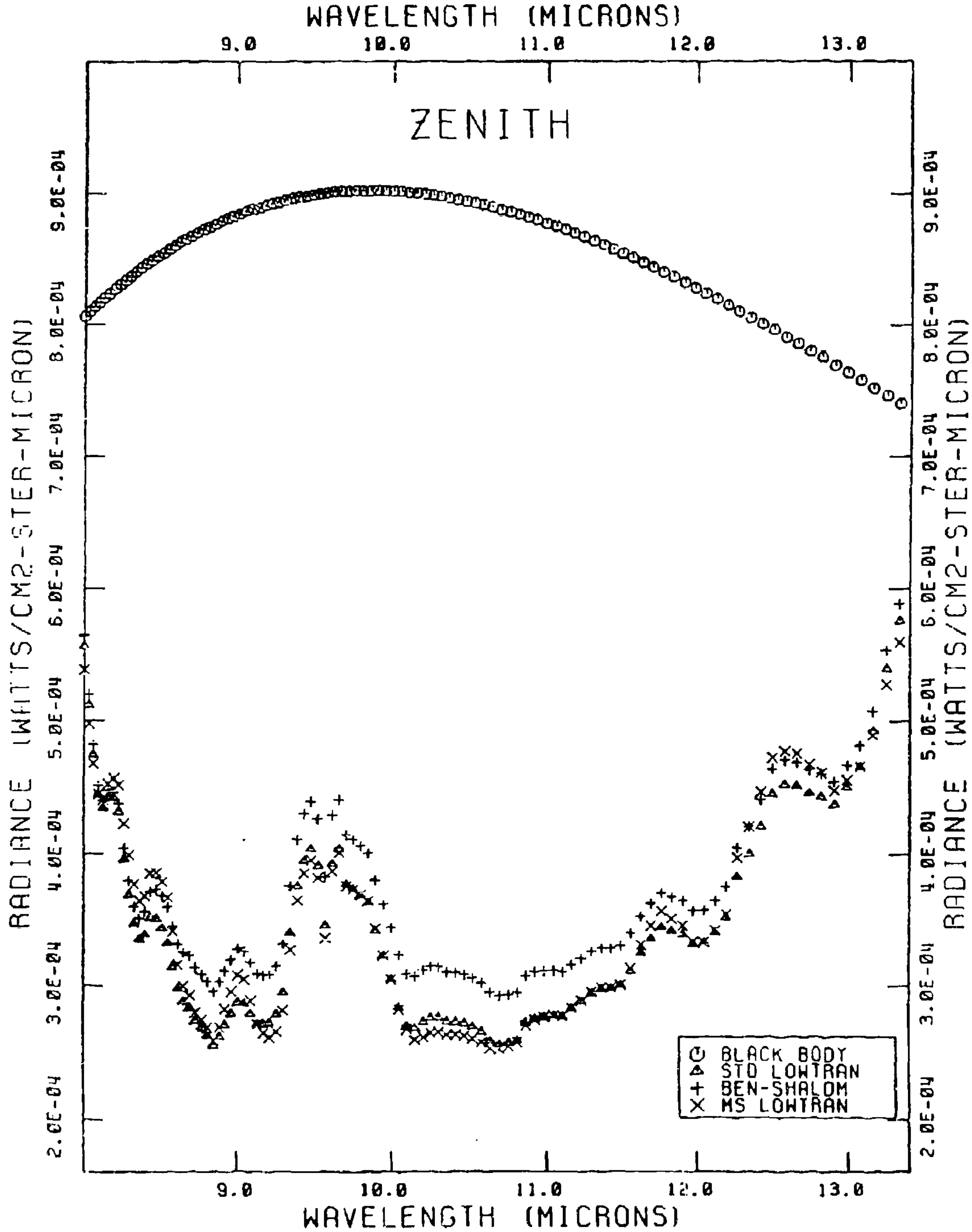


Figure 4-17. Downward thermal radiance comparison between 8 and 13.5 μm: Black body radiance of lowest atmospheric layer, standard LOWTRAN (without multiple scattering), Ben-Shalom calculations, and new LOWTRAN (with multiple scattering). Viewing path is from surface to zenith.

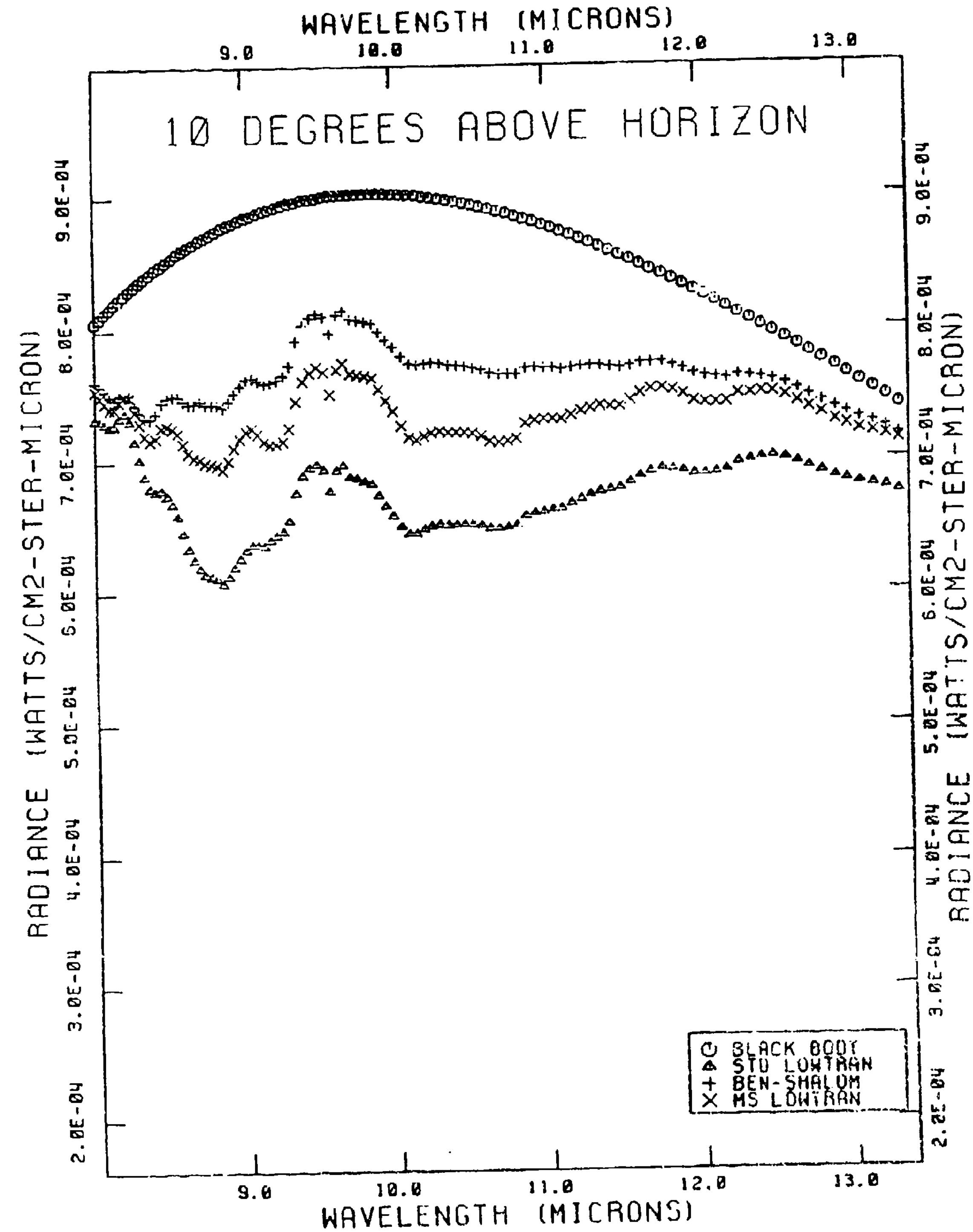


Figure 4-18. Downward thermal radiance comparison between 8 and 13.5 μm: Black body radiance of lowest atmospheric layer, standard LOWTRAN (without multiple scattering), Ben-Shalom calculations, and new LOWTRAN (with multiple scattering). Viewing path is from the surface to space with a zenith angle of 80° (10° above horizon).

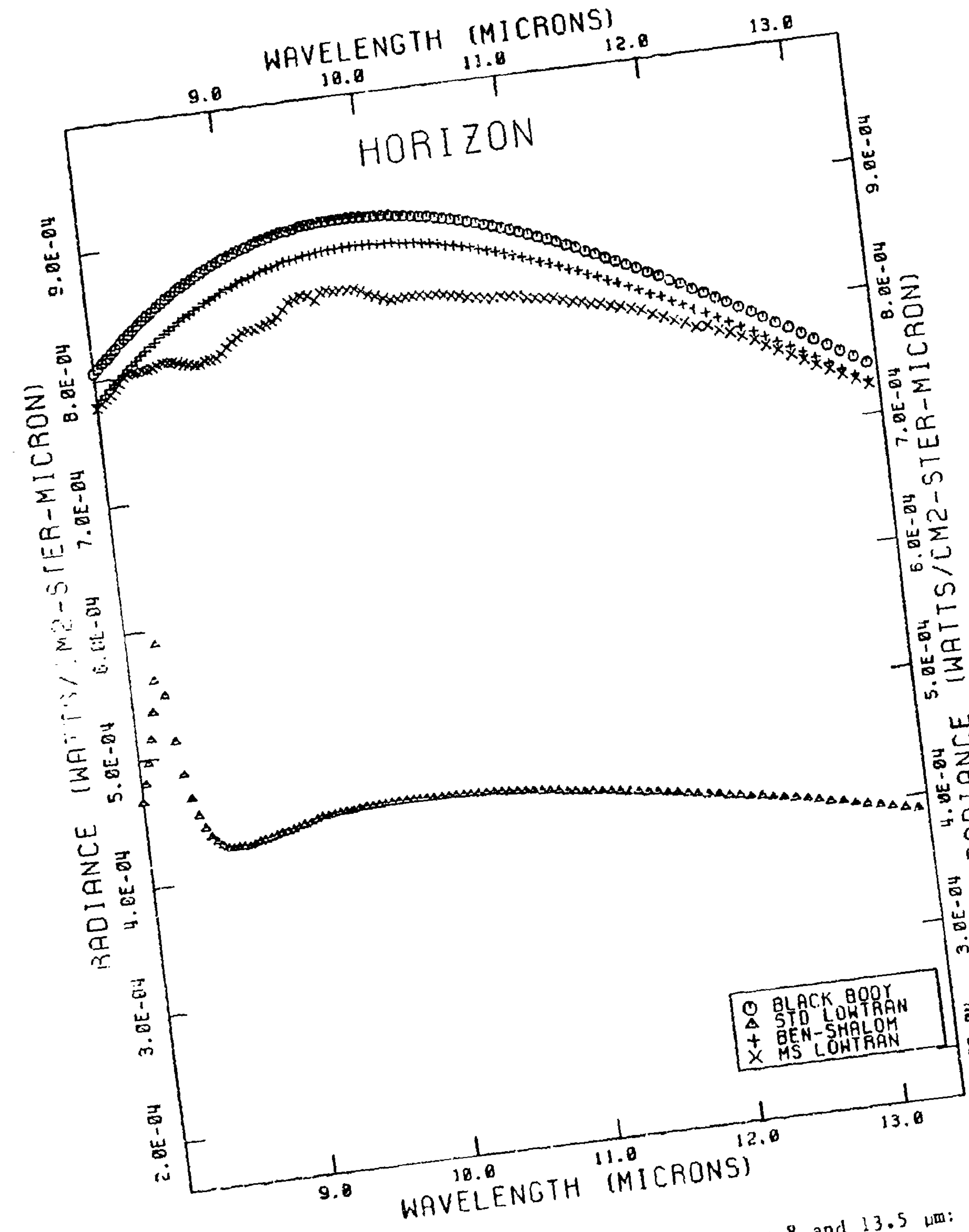


Figure 4-19. Downward thermal radiance comparison between 8 and 13.5 µm: Black body radiance of lowest atmospheric layer, standard LOWTRAN (without multiple scattering), Ben-Shalom calculations, and new LOWTRAN (with multiple scattering). Viewing path is from the surface to the horizon.

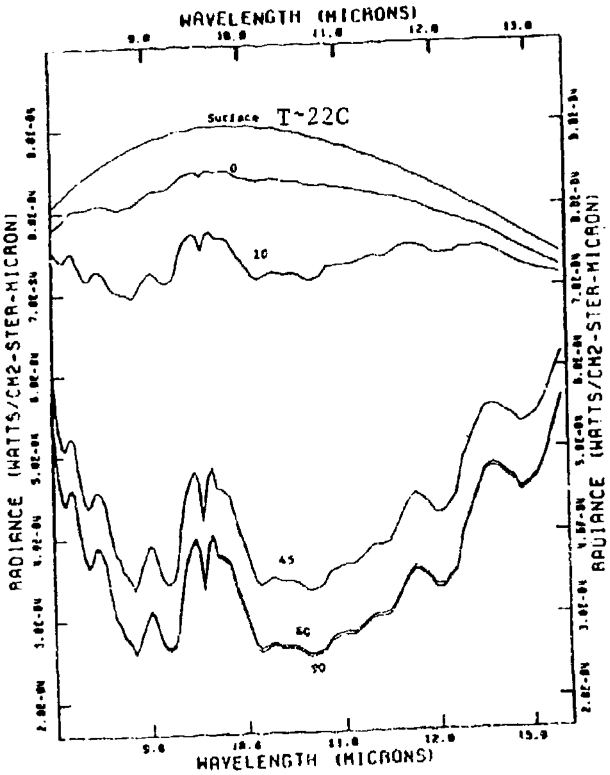


Figure 4-20a.

Downward thermal radiance results from LOWTRAN with multiple scattering (8.0 to 13.5 μm). Viewing path elevation angle varies between 0 to 90°. Also included is the black body radiance of the lowest atmospheric layer (~22°C).

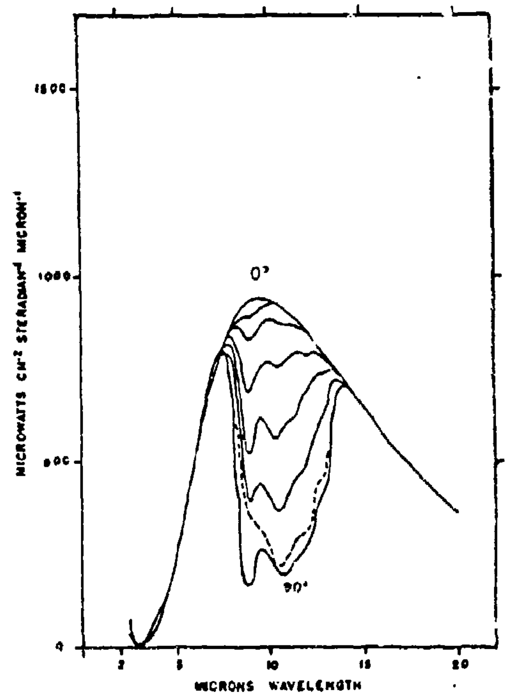


Figure 4-20b.

Downward radiance measurements for various viewing angles under atmospheric conditions qualitatively similar to those of Figure 4.20a (from Bell et al., 1960).

5. SUMMARY AND CONCLUSIONS

5.1 Summary

The goal of this research has been to provide a suitable parameterization of multiple scattering for implementation within the LOWTRAN and FASCODE atmospheric transmittance/radiance models developed at AFGL. Due to the comprehensive spectral domains treated by these models it was desired to develop a uniform approach applicable to spectral regions from the ultraviolet to the millimeter wave. Furthermore for consistency, analogous approaches were desired for implementation in LOWTRAN and FASCODE. The specific nature of the chosen approach was also constrained by the requirements of desired accuracy and computational efficiency of these models and additionally by their inherent code structure. Code structure requirements were particularly limiting with respect to the FASCODE model.

After reviewing the relevant radiative transfer literature two potential candidate multiple scattering parameterizations were selected for testing. These were a stream approximation and a successive order of scattering approach. Extensive intercomparison tests were conducted to compare the accuracy and efficiency of these candidate approaches to exact numerical treatments in the solar, thermal, and microwave/millimeter wave scattering regimes. Based on the results of these intercomparisons it was decided that the stream approximation would provide the required degree of accuracv and the least computational level of effort.

Two additional considerations were factors in formulating appropriate approaches to introduce multiple scattering into the LOWTRAN and FASCODE models. First, in the case of LOWTRAN it was necessary to provide an interface between the molecular absorber band model treatment and the multiple scattering parameterization. To accomplish this task the k-distribution method was introduced. The k-distribution method effectively decouples the multiple scattering from the LOWTRAN treatment of a ngray gas absorption so that the spectral integration can be done properly.

Secondly, although multiple scattering approaches generally begin with a knowledge of the monochromatic optical properties of the entire path of interest, both LOWTRAN and FASCODE perform transmittance and radiance calculations on a layer-by-layer basis. Thus, in these models, the properties of the

overall path are not known until the end of the calculation. To further complicate matters, the spectral resolution of each FASCODE layer is determined by the appropriate pressure dependent average line width. Thus, for a given desired spectral domain, the resolution of each FASCODE layer increases with decreasing pressure and monochromatic optical data on the entire desired scattering path is never available. These characteristics of the FASCODE code structure led to the adoption of a layer adding approach in order to accommodate both the stream approximation and the layer-by-layer nature of the calculation.

Path dependent radiances at 900 cm^{-1} were calculated using the FASCODE implementation of the multiple scattering parameterization (FASCODEMS), the original FASCODE, and the discrete ordinate method. Comparison of these results indicates that the multiple scattering version of FASCODE provides more accurate radiance distribution in the presence of aerosol scattering. Our parametric studies indicate that accuracies of 15 to 20 percent should be expected. However, this increase in accuracy incurs an additional cost in code execution time. In our timing test, CPU execution times for a multiple scattering run in a three-hundred wave number region (800-1100 cm^{-1}), took about 3-1/2 times longer than a standard FASCODE run. Most of this additional time was due to the required spectral merging of stored quantities rather than calculations of the stream approximation. Additionally, multiple scattering runs of FASCODE require three times the temporary storage of regular FASCODE runs. The program size is increased by about 15 percent.

To insure consistency, LOWTRAN and FASCODE multiple scattering results were also compared. A much closer agreement is found between AER LOWTRAN and FASCODE (both use multiple scattering) than those between LOWTRAN6 (uses single scattering) and FASCODE.

5.2 Recommendations

This report has described recommendations and implementations of an approach to provide the LOWTRAN and FASCODE models with a unified treatment of multiple scattering consistent with described levels of accuracy and their respective code structures. Introduction of this capability has a number of implications which require additional consideration. These form the basis of our recommendations.

For FASCODE, the question of solar multiple scattering remains an open issue. Certainly, the line parameter compilation provides the capability to exercise FASCODE well below 2500 cm^{-1} where solar effects can influence path radiance. We did not introduce solar scattering into FASCODE since the necessary solar irradiance and single scattering routines from LOWTRAN are not yet a part of FASCODE2. If solar multiple scattering is desired in FASCODE, these routines and the capability to calculate the direct solar contribution and the scattering phase function (i.e., the solar path transmission) should be added to FASCODE, then a suitable coupling to the stream approximation/flux adding code segments could be implemented.

Likewise, although this report has illustrated the applicability of the scattering parameterization to the microwave and millimeterwave region for scattering by precipitation, the FASCODE model does not provide the necessary optical properties for such calculations. Attenuation (i.e., extinction) coefficients for rain are available in FASCODE; however, information on single scattering albedo (or alternatively, the scattering coefficients) and asymmetry factor are not. It would seem a simple matter to provide this data. A simple parameterization of these values in the domain between 19.35 and 231 GHz (0.65 - 7.7 cm^{-1}) is available in the interim (Isaacs et al., 1985).

With regard to LOWTRAN, we recommend that the k-values should be part of the laboratory experiments, i.e., they be provided directly from fitting the laboratory measurements of transmission values. The present setup of LOWTRAN can easily accommodate the updated k-values of different gases. The scaling approximation to treat inhomogeneous atmospheric effects needs to also be revised, perhaps utilizing the correlated-k techniques published by Wang and Ryan (1983).

Finally, it is worth noting that although the choice of the stream approximation for multiple scattering for implementation within the LOWTRAN and FASCODE models was not an arbitrary one, other approaches are possible. One criteria which the user may wish to consider is the trade-off between accuracy and computational level of effort. As implemented, the multiple scattering enhancements described here will provide emergent radiances with percent errors generally in the range of 10 to 30 percent for solar scattering and less than 10 percent for thermal scattering. Internal radiances, i.e., those evalauted for paths within the atmosphere, will be somewhat less accurate. These accuracies should be adequate for many simulation requirements. For users requiring higher accuracies, the code changes to LOWTRAN and FASCODE to accommodate multiple scattering have made it possible for experienced users of these models to access the necessary optical properties profiles for input to numerical multiple scattering algorithms. This can be accomplished by further modifying the LOWTRAN and FASCODE models to produce output files of the profiles of optical thickness, single scattering albedo, asymmetry factor, and/or angular scattering function which are used in the set up of the current stream approximation calculation.

Other possible options which may interest knowledgeable users include output of emergent fluxes or flux profiles (made possible by the inclusion of the two stream/adding step done in the stream approximation) and substituting other multiple scattering approximations (such as higher order stream approximations) within the code to obtain more accuracy. One application which we have not explored is the applicability of the implemented code changes to evaluation of multiply scattered visible and infrared radiances by clouds. A variety of exciting avenues are opened with the inclusion of the multiple scattering capability within LOWTRAN and FASCODE.

6. ACKNOWLEDGEMENTS

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APPENDIX A

REVIEW AND TRADE-OFF ANALYSIS OF MULTIPLE SCATTERING PARAMETERIZATIONS

A.1 Review of Multiple Scattering Parameterizations

Radiative transfer theory provides the mathematical description of the interaction between both external (e.g., incident solar) and internal (e.g., emitted thermal) sources of electromagnetic radiation and the optically active atmospheric constituents of gases and particulates (e.g., aerosols, clouds, and precipitation). The solution to the radiative transfer equation for a scattering atmosphere (Chandrasekhar, 1960; Goody, 1964; Liou, 1980) generally requires a numerical solution. An extensive variety of exact numerical methods have been developed to solve these equations over the years, and excellent review are available (Hansen and Travis, 1974; Shettle and Kuriyan, 1975; Lenoble, 1977). This section will focus on approximate multiple scattering methods which can be used as parameterizations applicable to both LOWTRAN and FASCODE models.

A.1.1 Solar Radiation

For practical purposes it is useful to categorize the extensive hierarchy of available computational procedures based on both the relative accuracy of the results required and the expenditure of computational resources incurred. A subjective evaluation according to these criteria results in four classes of method based on resultant accuracy characterized as either exact or approximate and computational methodologies denoted as either numerical or analytical. Exact methods are defined as those which agree among themselves to some acceptable degree of accuracy when applied to a variety of diverse problems. All other methods are approximate. The most recent intercomparison of exact methods suggests that about 1% accuracy in radiance can be expected (Lenoble, 1977). A variety of exact, numerical methods are listed in Table A-1 along with representative literature citations. The essential difference between numerical and analytical approaches is that the latter generally require less computer time. Analytical approaches are those which are generally implementable using simple algebraic relations supported by a priori specifiable parameters, i.e., there are no recurrent or iterative calculations and no convergence criteria. Exact analytical methods are available only for

Table A-1

Exact Numerical Multiple Scattering Computation Techniques

Name	Representative References
Successive Orders of Scattering*	van de Hulst (1948) Irvine (1965) Nagel et al. (1978)
Gauss-Seidel	Herman and Browning (1965) Dave (1972)
Doubling and Adding	van de Hulst (1963, 1971) Hansen (1969a,b)
Monte Carlo*	Collins and Wells (1965) Plass and Kattawar (1968)
Discrete Ordinates	Chandrasekhar (1960) Liou (1973)
Spherical Harmonics*	Bergstrom and Viskanta (1972) Dave and Canosa (1974)
Invariant Imbedding	Bellman, Kalaba, and Wing (1960)
Variational-iterative†	Sze (1976) Burke and Sze (1977)

*Represented in IAMAP Radiation Commission intercomparison, Lenoble, 1977)

†Isotropic scattering only

a few cases which are, unfortunately, not immediately applicable to general terrestrial radiance simulation situations. These cases include, for the most part, approaches based on Chandrasekhar's H functions for semi-infinite atmospheres ($\tau = \infty$) and X and Y functions for finite atmospheres (Chandrasekhar, 1960). For the former set of problems, for example, solutions are available for isotropic, Rayleigh and various anisotropic phase functions. For finite atmospheres, solutions are available only for isotropic (Carlstedt and Mullikan, 1966) and Rayleigh scattering (Coulson et al., 1960). These exact treatments, often obtainable in the form of lookup tables, are useful as checks for the accuracy of both exact numerical methods and proposed approximate methods when applied to degenerate cases (such as isotropic scattering).

Approximate methods include those based on evaluating the first few tractable terms or orders of more extensive exact numerical treatments and those formulated specifically as approximations. In the former class of approximate methods, the philosophy is to accept the known risk of increased error for a specific application in order to benefit from reduced computer run time. Examples include terminating successive order of scattering approaches after a few scatterings (see Nagel et al., 1978), reducing the number of Legendre polynomials carried in the expansion of an angular scattering function, and limiting the number of quadrature angles in the discrete ordinate method. The method is approximate since the user knows a priori that the full available power of the exact numerical method at hand is not being exercised. For the simplest cases, these approaches often result in analytical solutions which may themselves be useful such as single and double scattering solutions (Deirmendjian, 1969; Hovenier, 1971), the two- and four-stream approximations based on the discrete ordinate method (Liou, 1973, 1974), and the two-step function approach based on general variational methods (Sze, 1976; Burke and Sze, 1977).

Multiple scattering methods formulated as intrinsically approximate have a common heritage in the estimation of radiation fluxes within larger numerical models (see Stephens, 1984). This applies both to the use of similarity relations to reduce anisotropic problems to isotropic equivalents (van de Hulst and Grossman, 1968) and various so-called two-stream approximations (Meader and Weaver, 1980). Notably, it is only recently that various investigators have sought approaches to treat the approximation of

multiply scattered radiances by augmenting a single scattering solution with an estimate of the multiply scattered radiance field based on a suitable flux parameterization. Included among these are: (a) the "diffuse field" approximation described by Bergstrom et al. (1981) for use in visibility impact models, (b) a path radiance approximation based on the delta-Eddington approach by Hering (1981) which was implemented within an operational visible contrast transmittance model, and (c) Kaufman's (1979) radiance approximation for applications to remote sensing. Kaufman has primarily applied his approximate scheme as a device to evaluate multiply scattered contributions to upward radiance within the context of multidimensional remote sensing (cf. Kaufman, 1982). Analogous solutions for downward radiance were derived by Isaacs (1981) for application to visibility model related radiance evaluation.

This overview of computational methods applicable to the simulation of radiances due to the multiple scattering of solar radiation suggests that a suitable parameterization may be found among one of the approximate approaches described above. In order to quantify this assessment, radiance comparisons were made between representative methods from each of the categories described above for a set of model atmospheres with aerosol content varying from ultra-clear to hazy conditions. Table A-2 summarizes the scattering treatments selected in this comparison. The Gauss-Seidel multiple scattering (MS) approach was selected to provide exact numerical radiance results for reference purposes (Dave and Gazdag, 1970). The algorithm used (Dave, 1972) evaluates fluxes and radiances for atmospheres with arbitrary vertical distribution of anisotropic aerosol extinction overlying a Lambert reflecting surface. When applied to pure molecular scattering cases, radiance results from the code reproduce the exact analytical tabulations of Coulson et al. (1960) based on Chandrasekhar's X and Y functions for Rayleigh scattering to high accuracy.

Three parameterization approaches were investigated. These include: (a) single scattering (SS), (b) a stream approximation (SA), and (c) successive orders of scattering (SOS). The SOS method (which is presently solved numerically) was formulated to treat the single scattered radiance exactly and to approximate higher order scattering by an isotropic angular scattering function. These approaches are summarized in Table A-3. Results of the test case comparisons are discussed in Section A.2.

Table A-2

Methods Selected for Intercomparison

Accuracy	Computational Effort: Numerical	Computational Effort: Analytical
Exact	Gauss-Seidel [MS] (Dave and Gazdag, 1970; Dave, 1972)	X,Y functions* (Chandrasekhar, 1960; Coulson et al., 1960)
Approximate	Successive Order of Scattering [SOS]	Single Scattering [SS] Stream Approximation [SA] (Kaufman, 1979)

*Rayleigh scattering only

Table A-3

Summary of Source Function, J, and Radiance, R, Evaluation Approaches for Three Candidate Approximation
(θ = temperature, T = transmittance, τ = optical depth)

	Single Scattering (SS)	Stream Approximation (SA)	Successive Scatterings (SOS)
Source Function, J	$J_o = \frac{\omega_o}{4} Fe^{-\tau/\mu_o} P(\Omega, -\Omega_o)$ $+ (1-\omega_o) B(\theta)$	$J^{\pm} = J_o + \frac{\omega}{\pi} [F^{\pm}(1-\beta)$ $+ \beta F^{\mp}]$	$J^n = J_o + \frac{\omega}{2} \int_o^{\tau^*} K(t,\tau) J^{n-1} dt$ $K(t,\tau) = E_1(\lvert t-\tau \rvert) + 2r E_2(\tau^*-t)$ $+ E_2(\tau^*-\tau)$
Radiance, R	$R = J_B T_b + \int_{T_b}^{1} J(T)\, dT$	same	same
Boundary Term J_B	$J_B = r\mu_o Fe^{-\tau/\mu_o}$ $+ (1-r) B(\theta_b)$	$J_B = r[\mu_o F_e^{-\tau/\mu_o} + \frac{F^-(T_b)}{\pi}]$ $+ (1-r) B(\theta_b)$	$J_B = r[\mu_o Fe^{-\tau/\mu_o}$ $+ 2 \int_o^{\tau^*} E_2(\tau^*-t) J(t)\, dt]$ $+ (1-r) B(\theta_b)$

A.1.2 Thermal Radiation

The detailed numerical schemes described in the previous section can be used to perform thermal radiation calculations by including the thermal emission term. For example, the doubling method has been extended by Wiscombe to include an inhomogeneous internal source (see Wiscombe, 1976 and the cited references for other detailed methods). Although these methods are useful for reference calculations, from practical considerations, the study of particle multiple scattering on atmospheric transmittance has to rely heavily on parameterizations. This is especially true for the LOWTRAN/FASCODE models.

Studies of the effects of aerosol multiple scattering on atmospheric infrared transmittance have emphasized the calculation of fluxes rather than radiances. The two-stream approach has been the commonly-used parameterization. In general, the two-stream approximation is a method of representing the radiation field in two streams in one-dimensional radiation transfer problems. The approximation, proposed by Schuster (1905) and Schwarzschild (1906), is to assume that the intensity in the positive direction is isotropic and that in the negative direction has a different value but is also isotropic. Chandrasekhar (1960) has used the Gaussian quadrature to approximate the integral over angle, terming this the "discrete ordinate" method. The first approximation of the discrete ordinate method results in the same form as the Schuster-Schwarzschild approximation except for different constant coefficients due to Gaussian division.

Sagan and Pollack (1967) and Piotrowski (1956) compared the approximation with the exact solutions for the cases of conservative and non-conservative isotropic scattering. The results show 5-10% accuracy in absolute values. A survey paper by Irvine (1968) has investigated several approximation methods, including two-stream, Eddington and modifed two-stream approximation. Uses of two-stream approximation for treating multiple scattering in thermal radiation are numerous (e.g., Rasool and Schneider, 1971; Wang and Domoto, 1974; Hansen et al., 1984). This parameterization has been used for climate application such as investigation of climatic effect due to aerosols (Hansen et al., 1980).

A.2 Trade-off Analysis of Exact and Approximate Treatments

A series of computer codes was written to support an intercomparison of angle dependent radiances from single scattering (SS), stream approximation

(SA), and successive orders of scattering (SOS) parameterizations with those evaluated using accurate numerical multiple scattering treatments. For the stream approximation, two independent flux treatments were employed, one for solar radiation and one for thermal radiation. The intercomparison calculations were performed by parametrically varying the relevant optical properties of optical depth, single scattering albedo, and asymmetry factor. Thus, they were offline from either the LOWTRAN or FASCODE models. Furthermore, these calculations assumed single homogeneous scattering layers.

Assessment criteria include accuracy defined in terms of computer execution times for a set of test cases and accuracy measured by intercomparison with numerical results.

A.2.1 Solar Scattering

For solar scattering, six model atmospheres were used in a comparison test consisting of one Rayleigh scattering case and five atmospheres including increasing amounts of aerosol. The vertical distribution of molecular density was that of the AFGL midlatitude summer model while that for the aerosol was Elterman's (1970) distribution. The turbidity weighting factor (defined as the ratio of total aerosol scattering optical depth to total scattering optical depth) varied from zero to near unity with corresponding surface visual ranges decreasing to about 1.2 km in haze. The optical properties of these model atmospheres are given in Table A-4. For each of the six test cases radiances were calculated using the SS, SOS, and SA methods at nine values of zenith angle, three values of azimuth angle, and two surface reflectances for both upward viewing from the surface and downward viewing from space (i.e., a total of 108 values). The solar zenith angle for all cases was 60°. Corresponding exact multiple scattering (MS) cases were evaluated using the Gauss-Seidel iterative method (Dave, 1972). The phase function used was based on the radiance values from the exact method, R(MS) and each approximate method [R(A), A=SS, SOS, SA], percent errors were calculated for the corresponding ith viewing angle, surface reflectance pair according to:

$$PE_i(A) = \left[\frac{R(MS)-R(A)}{R(MS)}\right] \times 100\% \qquad (A.1)$$

Table A-4

Optical Properties of Model Atmospheres used in Solar Scattering Comparison Tests ($\lambda = 0.55\ \mu m$)

Model Atmosphere	Optical Thicknesses				Turbidity Factor	Single Scattering Albedo	Visual Range (km)
	Rayleigh	Aerosol Scattering	Aerosol Absorption	Total			
Rayleigh	0.1	0.0	0.0	0.1	0.0	1.000	319.1*
Case 1	0.1	0.1220	0.0281	0.25	0.5494	0.8877	34.9
Case 2	0.1	0.3252	0.0749	0.50	0.7648	0.8502	14.0
Case 3	0.1	0.7317	0.1686	1.00	0.8798	0.8315	6.4
Case 4	0.1	1.5446	0.3558	2.00	0.9392	0.82213	3.1
Case 5	0.1	3.9836	0.91767	5.00	0.97551	0.81651	1.2

*Assuming no earth curvature effects and a Rayleigh scattering coefficient (for dry air at STP) of 0.01226 km^{-1} (Goody, 1964, p. 414).

Additionally in order to provide a measure of overall accuracy for each case, root mean square errors, RMS, were evaluated for each approximate method, A, and surface reflectance, r, according to:

$$\mathrm{RMS}(A,r) = \left(\sum_{i=1}^{54} \frac{1}{54} [\mathrm{PE}_i(A)]^2 \right)^{1/2} \qquad (A.2)$$

A comparison of RMS error according to Equ. (A.2) is summarized in Table A-5. For each of the approximations (single scattering, stream approximation, successive orders of scattering), RMS errors are provided for the six model atmospheres and two selected values of surface reflectance (r = 0.0, 0.4). The magnitude of RMS errors reported in Table A-5 for single scattering approximate those which would be obtained using the LOWTRAN6 single scattering option (IEMSCT = 2) for a like sun/observer geometry. Examining Table A-5, it is notable that the increase of RMS error with optical thickness is considerably less for the stream approximation and successive scattering method than for the single scatter parameterization. This is not surprising since the latter does not treat the multiply scattered radiance contribution which becomes increasingly important at larger optical thicknesses. At a moderate optical thickness (say 1.0, corresponding to an approximate visual range of 6.4 km) and zero surface reflectance the SOS and SA approaches are better by factors of about 1.5 and 2.0, respectively.

In order to provide a measure of efficiency for each approximation, execution times were tabulated for calculation of scattered radiances for the ensemble of eighteen upward and downward zenith angles, three azimuth angles, and two values of surface reflectance. These results are presented in Table A-6. The codes to evaluate each approximation were run on AER's Harris H800 and while not optimized for speed were configured for consistency with the layered atmosphere code structure of the LOWTRAN/FASCODE models. The exact multiple scattering (MS) execution times were obtained from comparison runs made on the AFGL CYBER. To provide a basis for comparison, Harris equivalent execution times (the values in parentheses) were estimated for each case using a benchmark execution of the Dave code from each machine to obtain a conversion factor of about 2.1. It is important to note that these times apply to the evaluation of the radiances from prespecified profiles of optical parameters and do not include time spent calculating atmospheric transmission.

Table A-5

Comparison RMS Errors for Single Scattering (SS), Stream Approximation (SA), and Successive Orders of Scattering (SOS)

Optical Thickness/ Reflectivity		SS	SA	SOS
0.10 (Rayleigh)	/0.0	13.5	4.3	4.5
	/0.4	29.2	10.4	3.6
0.25 (Case 1)	/0.0	33.4	12.2	17.9
	/0.4	41.8	4.9	18.8
0.50 (Case 2)	/0.0	50.4	17.2	29.5
	/0.4	57.6	9.4	31.9
1.00 (Case 3)	/0.0	67.0	29.1	43.3
	/0.4	72.5	23.2	48.6
2.00 (Case 4)	/0.0	80.8	34.0	58.1
	/0.4	83.3	30.3	63.5
5.00 (Case 5)	/0.0	90.0	39.1	73.1
	/0.4	90.5	40.1	73.7

It is interesting to compare execution times relative to the corresponding single scattering values. The stream approximation takes about two times longer regardless of optical thickness. This is of interest since the successive scattering execution times increase with increasing optical thickness and are at best eight times larger, although this could probably be shortened by careful optimization. Except for the Rayleigh case (which could be solved exactly anyway), multiple scattering execution times are at least an order of magnitude larger and increase slightly with optical thickness.

A.2.2 Thermal Scattering

A set of model atmosphere test cases was employed to compare each multiple scattering parameterization for thermal scattering with an exact numerical treatment. Spectral regions of interest included the infrared where scattering by aerosol and cloud can be a factor in determining the radiance

Table A-6

Comparison Execution Times for Single Scattering (SS), Stream Approximation of (SA), and Successive Order of Scattering (SOS) Methods

	Execution Time (sec)			
Optical Thickness	SS[1]	SA[1]	SOS[1]	MS[2,3]
0.10 (Rayleigh)	3.4	7.8	27.4	2.45 (5.1)
0.25 (Case 1)	3.4	7.8	37.6	47.64 (100.1)
0.50 (Case 2)	3.4	7.8	47.6	48.79 (102.5)
1.00 (Case 3)	3.4	7.8	63.4	50.14 (105.3)
2.00 (Case 4)	3.4	7.8	90.6	51.98 (109.2)
5.00 (Case 5)	3.4	7.8	107.8	52.92 (111.13)

[1]Harris H800 CPU time to evaluate radiances for eighteen upward and downward zenith angles, three azimuth angles and two values of surface reflectance, i.e., a total of 108 atmospheric paths.

[2]AFGL CYBER CPU execution time in seconds for multiple scattering (Dave, 1976) solution of same 108 atmospheric paths.

[3]Parentheses contain estimated Harris H800 execution times for comparison (the Rayleigh scattering case is actual) based on an H800/CYBER time factor of 2.1 obtained from a common benchmark run of the Dave code.

field and the microwave/millimeter wave where scattering is due largely to precipitation. Calculations were performed for similar sets of optical properties for the stream approximation (SA), successive orders of scattering (SOS), and an accurate numerical method for multiple scattering, the discrete ordinate method (DOM).

In order to maximize the effects of aerosol scattering in the infrared, a spectral region was selected (900 cm-1) where gaseous absorption is relatively weak. This window region, influenced primarily by water vapor continuum absorption, is used for remote sensing purposes such as surface temperature retrieval. The test comparisons were done parametrically with optical thicknesses in the range from 0.05 to 1.00, single scattering albedos between 0.5 and 0.9, and asymmetry factors between 0.6 and 0.8. These ranges were chosen both to include values representative of the 10-12 um window for typical haze conditions and to push the effect of scattering to unrealistically high values for testing purposes. The optical properties of the model atmospheres used in the thermal scattering comparison are summarized in Table A-7.

Table A-7

Optical Properties of Model Atmospheres Used in Thermal Scattering Comparison

	Optical Thickness	Single Scattering Albedo	Asymmetry Factor
Infrared Region (ν = 900 cm^{-1})			
Case 1 a,b	0.05	0.50, 0.75, 0.90	0.6, 0.7, 0.8
Case 2 a,b	0.25	0.50, 0.75, 0.90	0.6, 0.7, 0.8
Case 3 a,b	0.50	0.50, 0.75, 0.90	0.6, 0.7, 0.8
Case 4 a,b	1.00	0.50, 0.75, 0.90	0.6, 0.7, 0.8
Microwave/millimeter wave (f = 19.35, 37.00 GHz)			
Case 5 a,b (19.35 GHz)	0.906	0.21 (M-P, Rain rate 15 $mmhr^{-1}$)	Phase Function
Case 6 a,b (37.00 GHz)	3.20	0.39 (M-P, Rain rate 15 $mmhr^{-1}$)	Phase Function

a: Isothermal T_S = 288K, T_a = 283K

b: Gradient T_S = 288K, $\overline{T}_a$ = 283K

The surface temperature for all calculations was assumed to be 288 K. Two types of atmospheric temperature profile were investigated: an isothermal atmosphere with a temperature of 283 K and an atmosphere with a 10 K temperature gradient from top to bottom and a mean temperature of 283 K. These are called the isothermal and gradient atmospheres, respectively.

Microwave/millimeter wave calculations were done for cases with similar surface temperatures and temperature profiles. Two frequencies, 19.35 and 37.0 GHz (1.55 and 0.81 cm, respectively) corresponding to those used for satellite remote sensing were investigated. For these cases (see Table A-7), scattering was assumed due to a Marshall-Palmer distribution of rain with a rain rate of 15 mm/h. Precipitation scattering properties such as the extinction coefficient, single scattering albedo, and angular scattering fuction were evaluated from a parameterization of the Mie theory calculations of Savage (1978) developed for a millimeter wave simulation model (Isaacs et al., 1985).

The discrete ordinate method (DOM) (Liou, 1973) provided numerical solutions as a standard for comparison. A sixteen stream version of the DOM code was used. Radiance results were thus given at eight upward and eight downward zenith angles within the domains from 0 to 90 degrees (upward radiance) and 90 to 180 degrees (downward radiance). The endpoints of these ranges (i.e., 0, 90, and 180 degrees) are extrapolated from internal points and are thus not accurate values. To facilitate calculation of the required Legendre polynomial expansion of the angular scattering function, Henyey-Greenstein phase functions with the desired asymmetry factors were employed.

Results of the multiple scattering parameterization intercomparison were tabulated as radiances, percent errors as a function of zenith angle, and percent root mean squared (RMS) errors. The latter quantity was evaluated over all zenith angles used in the intercomparison. Sample results are shown in Figures A-1 to A-4. Figure A-1(a) and (b) illustrate the comparison between upward and downward emergent radiances, respectively, for the SA and SOS parameterizations and the exact DOM solution. This particular calculation is for an optical depth of 0.25, single scattering albedo of 0.9, and an asymmetry factor of 0.8. The SOS approach underestimates upward radiance and overestimates downward radiance compared to the DOM due to the assumption of isotropic scattering. The SA, however, reasonably reproduces the multiply scattered radiance field, except near the horizon (zenith angles approaching 90°).

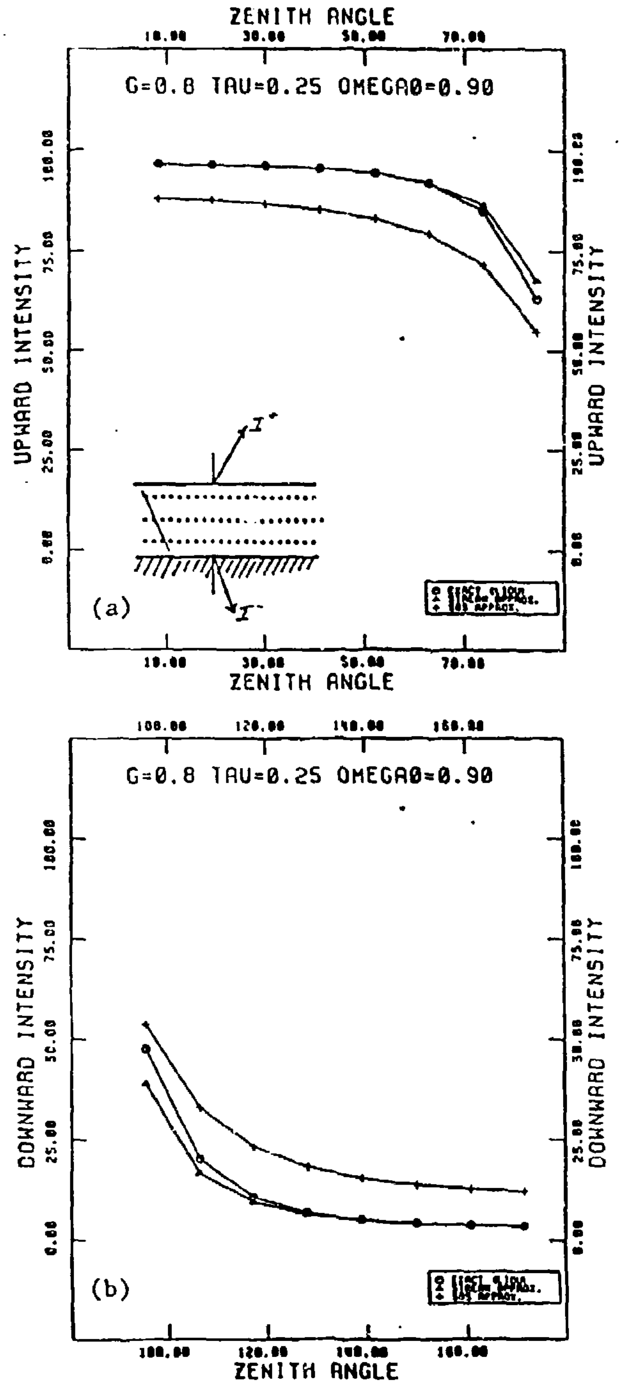

Figure A-1. Comparison of emergent radiances from DOM, SA, and SOS for $g = 0.8$, $\tau = 0.25$, $\omega_0 = 0.9$: (a) upward radiances, (b) downward radiances (units: erg sec^{-1} cm^{-1} str^{-1} $(cm^{-1})^{-1}$)

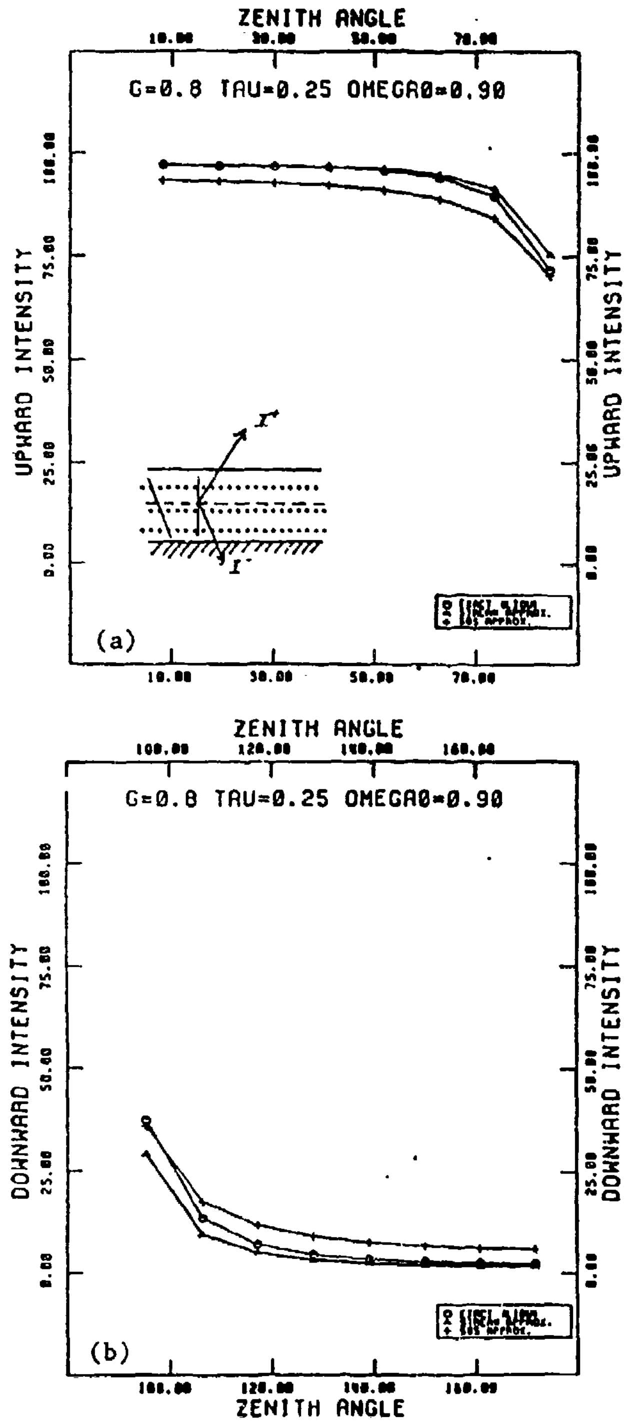

Figure A-2. Comparison of internal radiances from DOM, SA, and SOS for $g = 0.8$, $\tau = 0.25$, $\omega_o = 0.9$: (a) upward radiances, (b) downward radiances (units: erg sec^{-1} cm^{-1} str^{-1} $(cm^{-1})^{-1}$)

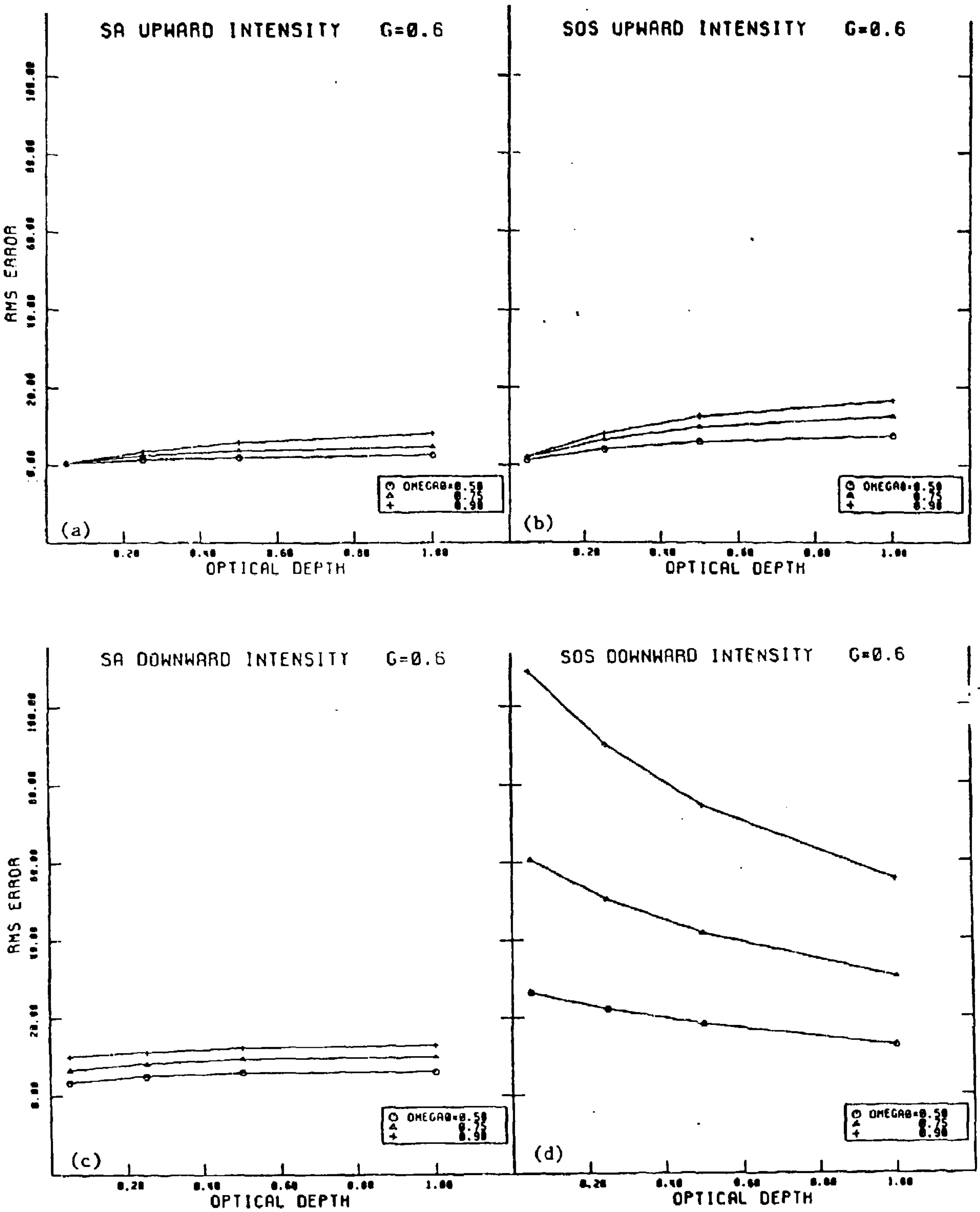

Figure A-3. Percent RMS erros for SA and SOS compared to DOM as a function of optical depth and single scattering albedo for g = 0.6: (a) SA upward radiance, (b) SOS upward radiance, (c) SA downward radiance, and (d) SOS downward radiance.

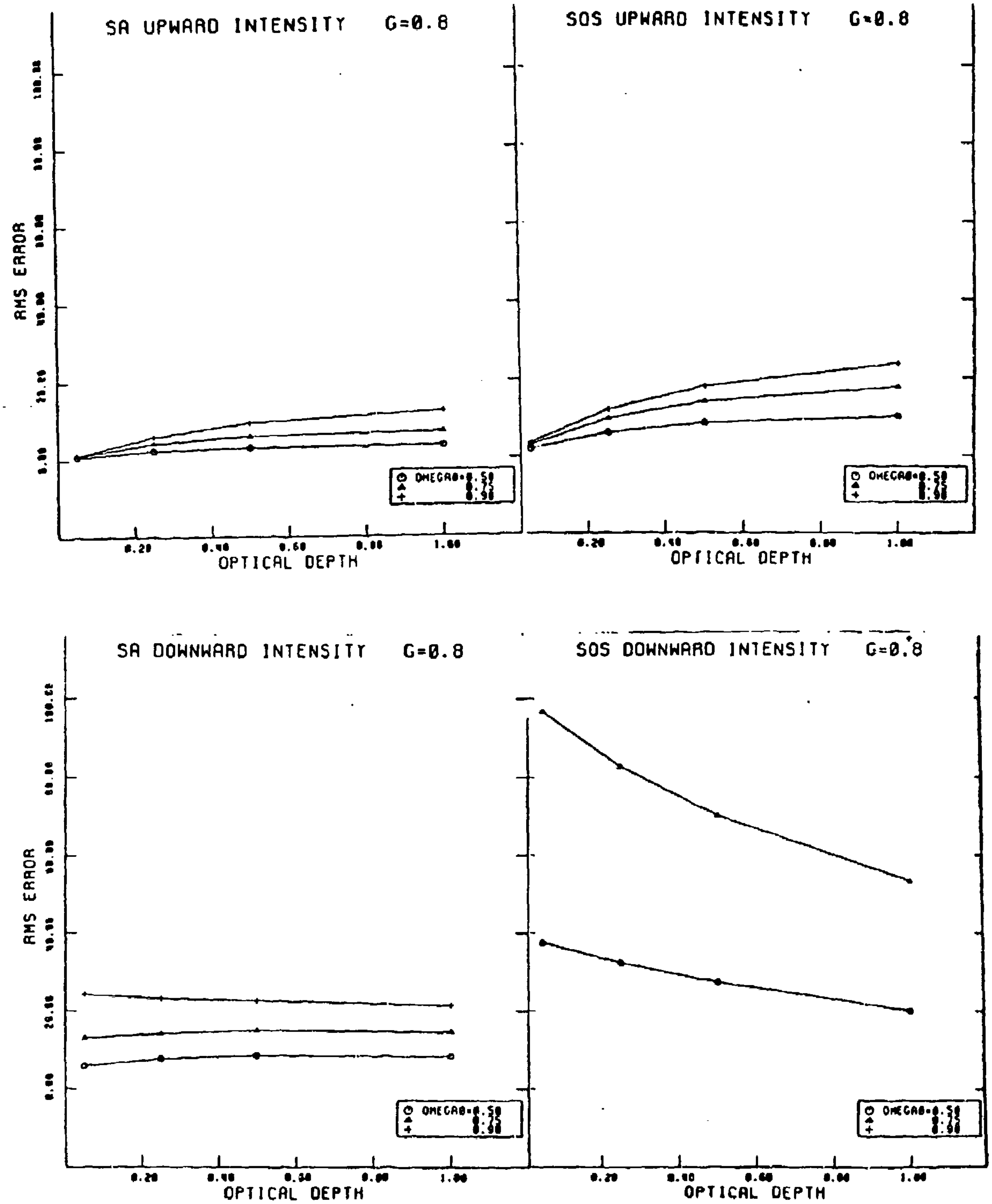

Figure A-4. Percent RMS erros for SA and SOS compared to DOM as a function of optical depth and single scattering albedo for g = 0.8: (a) SA upward radiance, (b) SOS upward radiance, (c) SA downward radiance, and (d) SOS downward radiance.

Similar conclusions can be drawn by looking at the internal upward and downward radiances halfway through the layer at an optical depth of 0.125 (Figures A-2(a) and (b), respectively).

Figures A-3 and A-4 illustrate the percent RMS error for the stream approximation and successive orders of scattering compared to the discrete ordinate solutions for all optical depths, and single scattering albedos, and scattering asymmetry factors of 0.6 and 0.8, respectively. While the SOS approach provides reasonable upward radiances with errors only slightly greater than the SA, SOS derived downward radiances are quite inaccurate. Downward radiances are a real test of the scattering parameterization since upward radiances are largely determined by the uniform surface emission at these optical depths. Notably, RMS errors for the stream approximation are weakly dependent on optical depth and are at most about 25 percent. Errors are largest for high single scattering albedo and asymmetry factor, i.e., when the scattering effect is maximum and when the angular scattering function is strongly forward scattering. This is expected due to the nature of the approximation used.

Computer execution times were also tabulated for each thermal scattering test case ensemble to ascertain their relative efficiency. Execution times are given in Table A-8. Times for the SOS and DOM are comparable while the SA was about 40 times faster than the DOM. These results suggest that the SA is the candidate parameterization of choice.

A.3 Recommendations for LOWTRAN and FASCODE

Based on these results, the stream approximation was selected for implementation for thermal scattering as well as solar scattering in the LOWTRAN and FASCODE models. Based on the evaluation and consideration of the requirements of efficiency, accuracy and code structure of LOWTRAN and FASCODE models, the parameterization of the stream approximation together with the correlated-k approximation is best suited for implementation into these models. The parameterization is unique in the sense that the correlated-k approximation decouples the multiple scattering from the treatment of nongray

Table A-8

Thermal Results

Execution Time (sec) Optical Thickness	SA	SOS	DOM (Liou)*
Tau = 0.05			
($g = 0.6$, $\omega_0 = 0.50$)	.35 (12.10)	6.28	5.76
($g = 0.6$, $\omega_0 = 0.90$)	.35 (12.10)	6.28	5.79
Tau = 0.25			
($g = 0.6$, $\omega_0 = 0.50$)	.34 (12.16)	7.55	5.79
($g = 0.6$, $\omega_0 = 0.90$)	.34 (12.19)	10.17	5.81
Tau = 0.50			
($g = 0.6$, $\omega_0 = 0.50$)	.34 (12.02)	8.87	5.72
($g = 0.6$, $\omega_0 = 0.90$)	.34 (12.15)	12.79	5.79
Tau = 1.00			
($g = 0.6$, $\omega_0 = 0.50$)	.34 (12.06)	10.14	5.74
($g = 0.6$, $\omega_0 = 0.90$)	.36 (12.22)	16.69	5.82

*Runs were made on AFGL's Cyber 750 system. All other runs on AER's Harris H800 system. Times in parenthesis are Harris equivalents for runs made on the Cyber, using a benchmark factor of 2.1.

gaseous absorption so that the stream approximation can be used to treat multiple scattering in both the LOWTRAN and FASCODE models. The stream approximation is extremely attractive since it retains the analytical simplicity (and hence, efficiency) of single scattering while improving the treatment of multiple-scattering (and hence, accuracy).

Appendix B

EXAMPLE OF FASCODE OUTPUT

A case is included as a test for FASCODE with multiple scattering. The input cards for the case are listed in Table B-1 and the listing of the file TAPE 6 is in Table B-2. The next section will discuss the output for the test case. Only those details which differ from the standard FASCODE output will be discussed.

This case demonstrates the new multiple scattering calculation for thermal scattering of downward radiance. The parameters selected for this case are as follows: the atmospheric profile is the 1962 U.S. Standard and the boundary layer aerosol model is RURAL with 5 km meteorological range. The path is a slant path from the ground to 20 km with a zenith angle at the ground of 0.0 degrees.

The output for this case shown in Table B-2 will now be described. The first difference is in CARD 2, which now contains another quantity, IMS. IMS is the eleventh variable printed on CARD 2, and is the flag for multiple scattering. When IMS is 1, the multiple scattering features of the program will be used. The next difference which occurs in the output, is a print of the path parameters which occurs on pages 2 and 3. This occurs due to a call to FSCGEO which is needed to determine whether or not the user defined path starts at or intersects the ground, and whether or not HMINMS and HMAXMS are contained within the user defined path. (This is explained further in the user instructions in Section 3.1.4. If additional paths were determined to be necessary in order to accommodate the multiple scattering calculation, these paths would be run and the corresponding output would appear in the calculations at this point. The user defined path would be the last path that would appear in the output.)

The next 25 pages in the output shown in Table B-2 are identical to those in the output for a run without multiple scattering. The following 21 pages which output the optical depths, radiance, and transmittance for each FASCODE layer are different for the multiple scattering runs. The differences will be discussed for one layer, since each layer has the same output. The first difference is that the radiance that is printed is the thermal emission and not the conservative scattering radiance supplied with the standard FASCODE

run. The second difference is that after the radiance and transmittance is printed, the composite upward flux and reflectance for that layer is also printed. These quantities are intermediate results used by the multiple scattering sections of the code, and are printed for the users benefit to see what the multiple scattering is doing.

That would conclude the output for the standard FASCODE run, but for the multiple scattering run, we still need to add the fluxes from the top down in order to determine the multiple scattered contribution. The next 21 pages are printout from the downward adding of the fluxes. The first page starts off with the composite downward flux and reflectance for layer 10. Then the total upward and downward flux for the top of layer 10 is printed. The next page prints out the composite downward flux and reflectance for layer 9. Then the total upward and downward flux for the top of layer 9 is printed. The next page starts with the output of the source function for the multiple scattering contribution to the radiance from Layer 10 (this quantity is actually the MS emission from layer 10). This is followed by the composite downward flux and reflectance for layer 8, followed by the total upward and downward flux for the top of layer 8. The source function for layer 9 appears at the top of the next page, and is followed by the total multiple scattered emission from both layer 9 and 10. This output scheme is continued such that on the last of the 21 pages the final MS emission that is printed is the total multiple scattering emission for the path.

The next and final page in the output is the total radiance for the FASCODE run and consists of the multiple scattered emission added to the thermal emission.

TABLE B-1

INPUT CARDS FOR THE FASCODE TEST CASE

Test Case

```
AER TEST CASE - MULTIPLE SCATTERING - RURAL AEROSOL = 900 - 910 CM-1
HI=1 F4=1 CN=1 AE=1 EM=1 SC=0 FI=0 PL=0 TS=0 AT=1 MG=0 LS=0 MS=1 RA=0     5    5
  200.20      1.000      0.0      15.0
  900.000   910.000      .000      .000      .000      .000      .000      .000
    0.000     1.000
   6    2    0    1    0    7    0           .000      .000      .000
   00.000    20.000   000.000      .000      .000    0
     .000      .000      .000      .000      .000
   2    0    0    0    6    0      .000      .000      .000      .000      .000
```

TABLE B-2

FASCODE OUTPUT FOR CASE 1

```
AER TEST CASE - MULTIPLE SCATTERING - RURAL AEROSOL * 900 - 910 CM-1     FASCOD2   86/07/15  16.04.54

   TIME ENTERING FASCODE       71.7040
 MIRAC     LBLF4     CNTNM     AERSL     EMISS     SCNFN     FILTR     PLOT     TEST     IATM     IMRG     ILAS     SCAT
   1         1         1         1         1         0         0         0        0        1        0        0        1
```

TABLE B-2 (Cont.)

```
*****PROGRAM FSCATM*****        86/07/15.     16.04.56.

CONTROL CARD 2.1: MODEL AND OPTIONS

        MODEL    =       6
        ITYPE    =       2
        IBMAX    =       0
        NOZERO   =       1
        NOPRNT   =       0
        NMOL     =       7
        IPUNCH   =       0
        RE       =          .000 KM
        HSPACE   =          .000 KM
        VBAR     =          .000 CM-1

CONTROL CARD 2.1 PARAMETERS WITH DEFAULTS:

        MODEL    =       6
        ITYPE    =       2
        IBMAX    =       0
        NOZERO   =       1
        NOPRNT   =       0
        NMOL     =       7
        IPUNCH   =       0
        RE       =    6371.230 KM

        HSPACE   =     100.000 KM
        VBAR     =     985.000 CM-1

SLANT PATH SELECTED, ITYPE =     2

CONTROL CARD 2.2:  SLANT PATH PARAMETERS

        H1       =         .0000 KM
        H2       =       20.0000 KM
        ANGLE    =         .0000 DEG
        RANGE    =         .0000 KM
        BETA     =         .0000 DEG
        LEN      =             0

AUTOLAYERING SELECTED

        AVTRAT   =      2.00
        TDIFF1   =     10.00

        TDIFF2   =     15.00
        ALTD1    =       .00
        ALTD2    =    100.00

CASE 2A: GIVEN H1, H2, ANGLE
```

TABLE B-2 (Cont.)

```
SLANT PATH PARAMETERS IN STANDARD FORM

         H1      =        .000 KM
         H2      =      20.000 KM
         ANGLE   =        .000 DEG
         PHI     =     180.000 DEG
         HMIN    =        .000 KM
         LEN     =           0

               ***** LOWTRAN 6 (MODIFIED)*****
 CARD 3.1 ****    2    0    0    0    0    0      .000      .000      .000      .000      .000

MODEL ATMOSPHERE NO.     6 ICLD =    0
```

CLOUD AND OR RAIN TYPE CHOSEN IS   NO CLOUD   M IS SET TO   7

Z (KM)	P (MB)	T (K)	REL H (%)	H2O (GM M-3)	CLD AMT (GM M-3)	RAIN RATE (MM HR-1)	TYPE	AEROSOL PROFILE	
.000	1013.000	288.20	45.92	5.904E+00	.000E+00	.000E+00	RURAL	RURAL	
1.000	898.800	281.70	49.07	4.201E+00	.000E+00	.000E+00	RURAL	RURAL	
2.000	795.000	275.20	52.03	2.901E+00	.000E+00	.000E+00	RURAL	RURAL	
3.000	701.200	268.70	50.78	1.800E+00	.000E+00	.000E+00	TROPOSPHERIC	TROPOSPHERIC	SPRING-SUMMER
4.000	616.600	262.20	50.10	1.100E+00	.000E+00	.000E+00	TROPOSPHERIC	TROPOSPHERIC	SPRING-SUMMER
5.000	540.500	255.70	48.43	6.402E-01	.000E+00	.000E+00	TROPOSPHERIC	TROPOSPHERIC	SPRING-SUMMER
6.000	472.200	249.20	49.25	3.801E-01	.000E+00	.000E+00	TROPOSPHERIC	TROPOSPHERIC	SPRING-SUMMER
7.000	411.100	242.70	46.22	2.101E-01	.000E+00	.000E+00	TROPOSPHERIC	TROPOSPHERIC	SPRING-SUMMER
8.000	356.500	236.20	50.61	1.200E-01	.000E+00	.000E+00	TROPOSPHERIC	TROPOSPHERIC	SPRING-SUMMER
9.000	308.000	229.70	37.14	4.602E-02	.000E+00	.000E+00	TROPOSPHERIC	TROPOSPHERIC	SPRING-SUMMER
10.000	265.000	223.30	28.73	1.800E-02	.000E+00	.000E+00	TROPOSPHERIC	TROPOSPHERIC	SPRING-SUMMER
11.000	227.000	216.80	27.47	8.202E-03	.000E+00	.000E+00	BACKGROUND STRATO	BACKGROUND STRATO	SPRING-SUMMER
12.000	194.000	216.70	12.54	3.700E-03	.000E+00	.000E+00	BACKGROUND STRATO	BACKGROUND STRATO	SPRING-SUMMER
13.000	165.800	216.70	6.10	1.800E-03	.000E+00	.000E+00	BACKGROUND STRATO	BACKGROUND STRATO	SPRING-SUMMER
14.000	141.700	216.70	2.85	8.403E-04	.000E+00	.000E+00	BACKGROUND STRATO	BACKGROUND STRATO	SPRING-SUMMER
15.000	121.100	216.70	2.05	6.058E-04	.000E+00	.000E+00	BACKGROUND STRATO	BACKGROUND STRATO	SPRING-SUMMER
16.000	103.500	216.70	1.39	4.091E-04	.000E+00	.000E+00	BACKGROUND STRATO	BACKGROUND STRATO	SPRING-SUMMER
17.000	88.500	216.70	1.16	3.409E-04	.000E+00	.000E+00	BACKGROUND STRATO	BACKGROUND STRATO	SPRING-SUMMER
18.000	75.650	216.70	.98	2.895E-04	.000E+00	.000E+00	BACKGROUND STRATO	BACKGROUND STRATO	SPRING-SUMMER
19.000	64.670	216.70	.84	2.491E-04	.000E+00	.000E+00	BACKGROUND STRATO	BACKGROUND STRATO	SPRING-SUMMER
20.000	55.290	216.70	.73	2.157E-04	.000E+00	.000E+00	BACKGROUND STRATO	BACKGROUND STRATO	SPRING-SUMMER
21.000	47.290	217.60	.57	1.873E-04	.000E+00	.000E+00	BACKGROUND STRATO	BACKGROUND STRATO	SPRING-SUMMER
22.000	40.470	218.60	.44	1.632E-04	.000E+00	.000E+00	BACKGROUND STRATO	BACKGROUND STRATO	SPRING-SUMMER
23.000	34.670	219.60	.35	1.437E-04	.000E+00	.000E+00	BACKGROUND STRATO	BACKGROUND STRATO	SPRING-SUMMER
24.000	29.720	220.60	.27	1.256E-04	.000E+00	.000E+00	BACKGROUND STRATO	BACKGROUND STRATO	SPRING-SUMMER
25.000	25.490	221.60	.21	1.104E-04	.000E+00	.000E+00	BACKGROUND STRATO	BACKGROUND STRATO	SPRING-SUMMER
27.500	17.468	224.04	.11	7.731E-05	.000E+00	.000E+00	BACKGROUND STRATO	BACKGROUND STRATO	SPRING-SUMMER
30.000	11.970	226.50	.06	5.414E-05	.000E+00	.000E+00	BACKGROUND STRATO	BACKGROUND STRATO	SPRING-SUMMER
32.500	8.293	231.45	.03	3.738E-05	.000E+00	.000E+00	METEORIC DUST	METEORIC DUST	SPRING-SUMMER
35.000	5.746	236.50	.01	2.501E-05	.000E+00	.000E+00	METEORIC DUST	METEORIC DUST	SPRING-SUMMER
37.500	4.062	243.35	.00	1.795E-05	.000E+00	.000E+00	METEORIC DUST	METEORIC DUST	SPRING-SUMMER
40.000	2.871	250.40	.00	1.249E-05	.000E+00	.000E+00	METEORIC DUST	METEORIC DUST	SPRING-SUMMER
100.000	.000	195.10	.00	1.209E-10	.000E+00	.000E+00	METEORIC DUST	METEORIC DUST	SPRING-SUMMER

PROGRAM WILL COMPUTE RADIANCE

ATMOSPHERIC MODEL
    TEMPERATURE = 6   1962 U S STANDARD
    WATER VAPOR = 6   1962 U S STANDARD
    OZONE = 6   1962 U S STANDARD

SLANT PATH, H1 TO H2
    H1 = .000 KM
    H2 = 20.000 KM

TABLE B-2 (Cont.)

```
ANGLE =        .000 DEG

RANGE =        .000 KM
BETA  =        .000 DEG
LEN   =       0

FREQUENCY RANGE
   V1 =        900.0 CM-1  (      11.11 MICROMETERS)
   V2 =        910.0 CM-1  (      10.99 MICROMETERS)
   DV =          5.0 CM-1
```

TABLE B-2 (Cont.)

ATMOSPHERIC PROFILES

I	Z	P	T	CNTMFRN	HNO3	AEROSOL 1	AEROSOL 2	AEROSOL 3	AEROSOL 4	AER1*RH	CIRRUS	RH
	(KM)	(MB)	(K)	MOL/CM2 KM	ATM CM/KM	(-)	(-)	(-)	(-)	(-)	(-)	(PERCNT)
1	.00	1013.000	288.2	.000E+00	.000E+00	7.700E-01	.000E+00	.000E+00	.000E+00	3.536E+01	.000E+00	4.592E+01
2	1.00	898.800	281.7	.000E+00	.000E+00	7.700E-01	.000E+00	.000E+00	.000E+00	3.778E+01	.000E+00	4.987E+01
3	2.00	795.000	275.2	.000E+00	.000E+00	6.210E-02	.000E+00	.000E+00	.000E+00	3.231E+00	.000E+00	5.203E+01
4	3.00	701.200	268.7	.000E+00	.000E+00	.000E+00	3.460E-02	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
5	4.00	616.600	262.2	.000E+00	.000E+00	.000E+00	1.850E-02	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
6	5.00	540.500	255.7	.000E+00	.000E+00	.000E+00	9.310E-03	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
7	6.00	472.200	249.2	.000E+00	.000E+00	.000E+00	7.710E-03	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
8	7.00	411.100	242.7	.000E+00	.000E+00	.000E+00	6.230E-03	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
9	8.00	356.500	236.2	.000E+00	.000E+00	.000E+00	3.370E-03	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
10	9.00	308.000	229.7	.000E+00	.000E+00	.000E+00	1.820E-03	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
11	10.00	265.000	223.3	.000E+00	.000E+00	.000E+00	1.140E-03	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
12	11.00	227.000	216.8	.000E+00	.000E+00	.000E+00	.000E+00	7.990E-04	.000E+00	.000E+00	.000E+00	.000E+00
13	12.00	194.000	216.7	.000E+00	.000E+00	.000E+00	.000E+00	6.410E-04	.000E+00	.000E+00	.000E+00	.000E+00
14	13.00	165.800	216.7	.000E+00	.000E+00	.000E+00	.000E+00	5.170E-04	.000E+00	.000E+00	.000E+00	.000E+00
15	14.00	141.700	216.7	.000E+00	.000E+00	.000E+00	.000E+00	4.420E-04	.000E+00	.000E+00	.000E+00	.000E+00
16	15.00	121.100	216.7	.000E+00	.000E+00	.000E+00	.000E+00	3.950E-04	.000E+00	.000E+00	.000E+00	.000E+00
17	16.00	103.500	216.7	.000E+00	.000E+00	.000E+00	.000E+00	3.820E-04	.000E+00	.000E+00	.000E+00	.000E+00
18	17.00	89.500	216.7	.000E+00	.000E+00	.000E+00	.000E+00	4.250E-04	.000E+00	.000E+00	.000E+00	.000E+00
19	18.00	75.650	216.7	.000E+00	.000E+00	.000E+00	.000E+00	5.200E-04	.000E+00	.000E+00	.000E+00	.000E+00
20	19.00	64.670	216.7	.000E+00	.000E+00	.000E+00	.000E+00	5.810E-04	.000E+00	.000E+00	.000E+00	.000E+00
21	20.00	55.290	216.7	.000E+00	.000E+00	.000E+00	.000E+00	5.890E-04	.000E+00	.000E+00	.000E+00	.000E+00
22	21.00	47.290	217.6	.000E+00	.000E+00	.000E+00	.000E+00	5.020E-04	.000E+00	.000E+00	.000E+00	.000E+00
23	22.00	40.470	218.6	.000E+00	.000E+00	.000E+00	.000E+00	4.200E-04	.000E+00	.000E+00	.000E+00	.000E+00
24	23.00	34.670	219.6	.000E+00	.000E+00	.000E+00	.000E+00	3.000E-04	.000E+00	.000E+00	.000E+00	.000E+00
25	24.00	29.720	220.6	.000E+00	.000E+00	.000E+00	.000E+00	1.980E-04	.000E+00	.000E+00	.000E+00	.000E+00
26	25.00	25.490	221.6	.000E+00	.000E+00	.000E+00	.000E+00	1.310E-04	.000E+00	.000E+00	.000E+00	.000E+00
27	27.50	17.468	224.0	.000E+00	.000E+00	.000E+00	.000E+00	6.595E-05	.000E+00	.000E+00	.000E+00	.000E+00
28	30.00	11.970	226.5	.000E+00	.000E+00	.000E+00	.000E+00	3.320E-05	.000E+00	.000E+00	.000E+00	.000E+00
29	32.50	8.293	231.4	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	2.333E-05	.000E+00	.000E+00	.000E+00
30	35.00	5.746	236.5	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	1.640E-05	.000E+00	.000E+00	.000E+00
31	37.50	4.062	243.4	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	1.145E-05	.000E+00	.000E+00	.000E+00
32	40.00	2.871	250.4	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	7.990E-06	.000E+00	.000E+00	.000E+00
33	100.00	.000	195.1	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	9.310E-10	.000E+00	.000E+00	.000E+00

TABLE B-2 (Cont.)

```
                    *****PROGRAM FSCATM*****      86/07/15.     16.04.59.

CONTROL CARD 2.1: MODEL AND OPTIONS

        MODEL    =     6
        ITYPE    =     2
        IBMAX    =     0
        NOZERO   =     1
        NOPRNT   =     0
        NMOL     =     7
        IPUNCH   =     0
        RE       =  6371.230 KM
        HSPACE   =   100.000 KM
        VBAR     =   905.000 CM-1

CONTROL CARD 2.1 PARAMETERS WITH DEFAULTS:

        MODEL    =     6
        ITYPE    =     2
        IBMAX    =     0
        NOZERO   =     1
        NOPRNT   =     0
        NMOL     =     7
        IPUNCH   =     0
        RE       =  6371.230 KM
        HSPACE   =   100.000 KM
        VBAR     =   905.000 CM-1

SLANT PATH SELECTED, ITYPE =     2

CONTROL CARD 2.2:  SLANT PATH PARAMETERS

        H1       =     .0000 KM
        H2       =   20.0000 KM
        ANGLE    =     .0000 DEG

        RANGE    =     .0000 KM
        BETA     =     .0000 DEG
        LEN      =         0
```

TABLE B-2 (Cont.)

ATMOSPHERIC PROFILE SELECTED IS: M = 6 U. S. STANDARD, 1976

I	Z (KM)	P (MB)	T (K)	REFRACT INDEX-1 *1.0E6	DENSITY (MOLS CM-3) AIR	H2O	CO2	O3	N2O	CO	CH4	O2
1	.000	1013.00000	288.20	271.94	2.55E+19	1.97E+17	8.41E+15	6.78E+11	8.15E+12	3.82E+12	4.33E+13	5.33E+18
2	1.000	898.80000	281.70	246.92	2.31E+19	1.40E+17	7.63E+15	6.78E+11	7.40E+12	3.35E+12	3.93E+13	4.82E+18
3	2.000	795.00000	275.20	223.62	2.09E+19	9.70E+16	6.91E+15	6.78E+11	6.70E+12	2.93E+12	3.56E+13	4.38E+18
4	3.000	701.20000	268.70	202.05	1.89E+19	6.02E+16	6.24E+15	6.27E+11	6.05E+12	2.55E+12	3.21E+13	3.95E+18
5	4.000	616.60000	262.20	182.11	1.70E+19	3.68E+16	5.62E+15	5.77E+11	5.45E+12	2.22E+12	2.90E+13	3.56E+18
6	5.000	540.50000	255.70	163.71	1.53E+19	2.14E+16	5.06E+15	5.77E+11	4.90E+12	1.99E+12	2.50E+13	3.20E+18
7	6.000	472.20000	249.20	146.76	1.37E+19	1.27E+16	4.53E+15	5.65E+11	4.39E+12	1.78E+12	2.33E+13	2.87E+18
8	7.000	411.10000	242.70	131.20	1.23E+19	7.02E+15	4.05E+15	6.15E+11	3.90E+12	1.54E+12	2.09E+13	2.57E+18
9	8.000	356.50000	236.20	116.91	1.09E+19	4.01E+15	3.61E+15	6.53E+11	3.50E+12	1.31E+12	1.86E+13	2.29E+18
10	9.000	308.00000	229.70	103.87	9.71E+18	1.54E+15	3.21E+15	8.91E+11	3.11E+12	1.07E+12	1.65E+13	2.03E+18
11	10.000	265.00000	223.30	91.93	8.60E+18	6.02E+14	2.84E+15	1.13E+12	2.73E+12	8.60E+11	1.45E+13	1.80E+18
12	11.000	227.00000	216.80	81.11	7.58E+18	2.74E+14	2.50E+15	1.63E+12	2.38E+12	6.83E+11	1.27E+13	1.59E+18
13	12.000	194.00000	216.70	69.35	6.48E+18	1.24E+14	2.14E+15	2.01E+12	2.01E+12	5.19E+11	1.08E+13	1.35E+16
14	13.000	165.80000	216.70	59.27	5.54E+18	6.02E+13	1.83E+15	2.13E+12	1.69E+12	3.60E+11	9.12E+12	1.16E+18
15	14.000	141.70000	216.70	50.65	4.74E+18	2.81E+13	1.56E+15	2.38E+12	1.42E+12	2.37E+11	7.71E+12	9.90E+17
16	15.000	121.10000	216.70	43.29	4.05E+18	2.03E+13	1.34E+15	2.63E+12	1.19E+12	1.62E+11	6.50E+12	8.46E+17
17	16.000	103.50000	216.70	37.00	3.46E+18	1.37E+13	1.14E+15	3.01E+12	9.96E+11	1.04E+11	5.48E+12	7.24E+17
18	17.000	88.50000	215.70	31.64	2.96E+18	1.14E+13	9.77E+14	3.51E+12	8.24E+11	7.40E+10	4.60E+12	6.19E+17
19	18.000	75.65000	216.70	27.04	2.53E+18	9.68E+12	8.35E+14	4.02E+12	6.76E+11	5.06E+10	3.85E+12	5.29E+17
20	19.000	64.67000	216.70	23.12	2.16E+18	8.33E+12	7.14E+14	4.39E+12	5.47E+11	3.24E+10	3.22E+12	4.52E+17
21	20.000	55.29000	216.70	19.76	1.85E+18	7.21E+12	6.10E+14	4.77E+12	4.37E+11	2.40E+10	2.63E+12	3.86E+17
22	21.000	47.29000	217.60	16.83	1.57E+18	6.26E+12	5.20E+14	4.77E+12	3.46E+11	1.89E+10	2.13E+12	3.29E+17
23	22.000	40.47000	218.60	14.34	1.34E+18	5.46E+12	4.43E+14	4.89E+12	2.75E+11	1.61E+10	1.71E+12	2.80E+17
24	23.000	34.67000	219.60	12.23	1.14E+18	4.80E+12	3.78E+14	4.77E+12	2.25E+11	1.49E+10	1.36E+12	2.39E+17
25	24.000	29.72000	220.60	10.44	9.76E+17	4.20E+12	3.22E+14	4.52E+12	1.83E+11	1.37E+10	1.09E+12	2.04E+17
26	25.000	25.49000	221.60	8.91	8.33E+17	3.69E+12	2.75E+14	4.27E+12	1.46E+11	1.33E+10	8.80E+11	1.74E+17
27	27.500	17.43000	224.00	6.03	5.64E+17	2.58E+12	1.86E+14	3.27E+12	8.96E+10	1.02E+10	5.57E+11	1.18E+17
28	30.000	11.97000	226.50	4.09	3.83E+17	1.81E+12	1.26E+14	2.51E+12	5.42E+10	7.66E+09	3.50E+11	8.00E+16
29	32.500	8.01000	230.00	2.70	2.52E+17	1.22E+12	8.33E+13	1.86E+12	2.94E+10	5.72E+09	2.09E+11	5.28E+16
30	35.000	5.74600	236.50	1.88	1.76E+17	8.63E+11	5.81E+13	1.38E+12	1.63E+10	4.49E+09	1.31E+11	3.69E+16
31	37.500	4.15000	242.90	1.32	1.24E+17	6.13E+11	4.09E+13	9.66E+11	8.29E+09	3.59E+09	8.19E+10	2.59E+16
32	40.000	2.87100	250.40	.89	8.30E+16	4.18E+11	2.74E+13	6.07E+11	3.75E+09	4.99E+09	4.69E+10	1.74E+16
33	42.500	2.06000	257.30	.62	5.80E+16	2.99E+11	1.91E+13	3.60E+11	1.60E+09	5.16E+09	2.68E+10	1.21E+16
34	45.000	1.49100	264.20	.44	4.09E+16	2.14E+11	1.35E+13	2.15E+11	6.51E+08	5.39E+09	1.49E+10	9.55E+15
35	47.500	1.09000	270.60	.31	2.92E+16	1.53E+11	9.64E+12	1.20E+11	2.74E+08	5.71E+09	8.10E+09	6.10E+15
36	50.000	.79780	270.70	.22	2.13E+16	1.12E+11	7.05E+12	6.62E+10	1.02E+08	6.19E+09	4.49E+09	4.46E+15
37	55.000	.42500	260.80	.13	1.18E+16	6.02E+10	3.90E+12	2.13E+10	2.23E+07	5.32E+09	1.95E+09	2.47E+15
38	60.000	.21900	247.00	.07	6.42E+15	3.05E+10	2.12E+12	7.07E+09	4.52E+06	4.50E+09	8.38E+08	1.34E+15
39	65.000	.10900	233.30	.04	3.38E+15	1.42E+10	1.12E[illegible]	2.37E+09	8.54E+05	4.48E+09	3.50E+08	7.08E+14
40	70.000	.05220	219.60	.02	1.72E+15	6.03E+09	5.69E+11	5.17E+08	1.54E+05	4.31E+09	1.42E+08	3.60E+14
41	75.000	.02400	208.40	.01	8.34E+14	2.36E+09	2.75E+11	2.09E+08	2.62E+04	2.86E+09	5.49E+07	1.74E+14
42	80.000	.01050	198.60	.00	3.83E+14	7.86E+08	1.26E+11	1.15E+08	4.22E+03	1.80E+09	2.01E+07	8.01E+13
43	85.000	.00446	186.90	.00	1.71E+14	2.28E+08	5.65E+10	8.56E+07	6.60E+02	1.17E+09	7.18E+06	3.58E+13

44	90.000	.00184	186.90	.00	7.13E+13	6.07E+07	2.35E+10	5.00E+07	9.64E+01	7.14E+08	2.40E+06	1.49E+13
45	95.000	.00076	188.40	.00	2.92E+13	1.58E+07	9.65E+09	2.05E+07	1.38E+01	3.00E+08	7.85E+05	6.08E+12
46	100.000	.00032	195.10	.00	1.19E+13	4.04E+06	3.92E+09	4.76E+06	1.97E+00	1.25E+08	2.55E+05	2.38E+12

CASE 2A: GIVEN H1, H2, ANGLE

SLANT PATH PARAMETERS IN STANDARD FORM

H1	=	.000 KM
H2	=	20.000 KM
ANGLE	=	.000 DEG
PHI	=	180.000 DEG
HMIN	=	.000 KM
LEN	=	0

FASCODE LAYER BOUNDARIES PRODUCED BY THE AUTOMATIC LAYERING ROUTINE AUTLAY

THE USER SHOULD EXAMINE THESE BOUNDARIES AND MODIFY THEM IF APPROPRIATE
THE FOLLOWING PARAMETERS ARE USED:

AVTRAT	=	2.00	= MAX RATIO OF VOIGT WIDTHS
TDIFF1	=	10.00	= MAX TEMP DIFF AT 0. KM
TDIFF2	=	15.00	= MAX TEMP DIFF AT 100. KM
ALZERO	=	.100 CM-1	= AVERAGE LORENTZ WIDTH AT STP
AVMWT	=	36.00	= AVERAGE MOLECULAR WEIGHT
VBAR	=	905.00 CM-1	= AVERAGE WAVENUMBER

I	Z (KM)	P (MB)	T (K)	LORENTZ (CM-1)	DOPPLER (CM-1)	ZETA	VOIGT (CM-1)	VOIGT RATIO	TEMP DIFF (K)
1	.000	1013.00000	288.20	.10132	.00092	.991	.10133	1.18	9.8
2	1.500	845.30823	278.45	.08601	.00090	.990	.08602	1.18	9.8
3	3.000	701.20000	268.70	.07263	.00089	.986	.07264	1.19	9.8
4	4.500	577.29741	258.95	.06091	.00087	.986	.06093	1.20	9.8
5	6.000	472.20000	249.20	.05079	.00085	.983	.05080	1.21	9.8
6	7.500	382.82783	239.45	.04201	.00084	.980	.04202	1.22	9.8
7	9.000	308.00000	229.70	.03451	.00082	.977	.03453	1.25	10.3
8	10.600	241.49818	219.40	.02768	.00080	.972	.02771	1.98	2.7
9	15.000	121.10000	216.70	.01397	.00080	.946	.01401	1.98	.0
10	19.400	60.74878	216.70	.00701	.00080	.896	.00710	1.98	3.9
11	24.000	29.72000	220.60	.00340	.00080	.809	.00358	2.01	5.6
12	29.700	12.52214	226.20	.00141	.00081	.635	.00178	1.50	11.1
13	35.300	5.52596	237.27	.00061	.00083	.423	.00119	1.15	11.3
14	39.400	3.13044	248.60	.00034	.00085	.284	.00104	1.07	11.5
15	43.500	1.81014	260.06	.00019	.00087	.190	.00097	1.09	1.2
16	55.700	.38733	258.87	.00004	.00087	.045	.00089	1.04	12.4
17	60.200	.21297	246.45	.00002	.00085	.026	.00086	1.03	12.6
18	64.800	.11208	233.85	.00001	.00083	.015	.00083	1.03	12.9
19	69.500	.05619	220.97	.00001	.00080	.008	.00081	1.03	13.2
20	75.300	.02264	207.81	.00000	.00078	.003	.00078	1.04	13.5
21	82.200	.00720	194.33	.00000	.00075	.001	.00075	1.00	.8

TABLE B-2 (Cont.)

TABLE B-2 (Cont.)

CALCULATION OF THE REFRACTED PATH THROUGH THE ATMOSPHERE

I	ALTITUDE FROM (KM)	ALTITUDE TO (KM)	THETA (DEG)	DRANGE (KM)	RANGE (KM)	DBETA (DEG)	BETA (DEG)	PHI (DEG)	DBEND (DEG)	BENDING (DEG)	PBAR (MB)	TBAR (K)	RHOBAR (MOL CM-3)
	H1 TO H2												
1	.000	1.000	.000	1.000	1.000	.000	.000	180.000	.000	.000	965.683	284.990	2.43E+19
2	1.000	1.500	.000	.500	1.500	.000	.000	180.000	.000	.000	872.002	280.085	2.25E+19
3	1.500	2.000	.000	.500	2.000	.000	.000	180.000	.000	.000	820.105	276.835	2.15E+19
4	2.000	3.000	.000	1.000	3.000	.000	.000	180.000	.000	.000	747.913	271.992	1.99E+19
5	3.000	4.000	.000	1.000	4.000	.000	.000	180.000	.000	.000	658.727	265.493	1.80E+19
6	4.000	4.500	.000	.500	4.500	.000	.000	180.000	.000	.000	596.908	260.586	1.66E+19
7	4.500	5.000	.000	.500	5.000	.000	.000	180.000	.000	.000	558.860	257.336	1.57E+19
8	5.000	6.000	.000	1.000	6.000	.000	.000	180.000	.000	.000	506.204	252.495	1.45E+19
9	6.000	7.000	.000	1.000	7.000	.000	.000	180.000	.000	.000	441.516	245.996	1.30E+19
10	7.000	7.500	.000	.500	7.500	.000	.000	180.000	.000	.000	396.932	241.087	1.19E+19
11	7.500	8.000	.000	.500	8.000	.000	.000	180.000	.000	.000	369.634	237.837	1.13E+19
12	8.000	9.000	.000	1.000	9.000	.000	.000	180.000	.000	.000	332.137	232.999	1.03E+19
13	9.000	10.000	.000	1.000	10.000	.000	.000	180.000	.000	.000	286.399	226.550	9.14E+18
14	10.000	10.600	.000	.600	10.600	.000	.000	180.000	.000	.000	253.215	221.369	8.28E+18
15	10.600	11.000	.000	.400	11.000	.000	.000	180.000	.000	.000	234.235	218.108	7.78E+18
16	11.000	12.000	.000	1.000	12.000	.000	.000	180.000	.000	.000	210.499	216.751	7.02E+18
17	12.000	13.000	.000	1.000	13.000	.000	.000	180.000	.000	.000	179.900	216.700	6.00E+18
18	13.000	14.000	.000	1.000	14.000	.000	.000	180.000	.000	.000	153.750	216.700	5.13E+18
19	14.000	15.000	.000	1.000	15.000	.000	.000	180.000	.000	.000	131.400	216.700	4.38E+18
20	15.000	16.000	.000	1.000	16.000	.000	.000	180.000	.000	.000	112.300	216.700	3.75E+18
21	16.000	17.000	.000	1.000	17.000	.000	.000	180.000	.000	.000	96.002	216.700	3.20E+18
22	17.000	18.000	.000	1.000	18.000	.000	.000	180.000	.000	.000	82.075	216.700	2.74E+18
23	18.000	19.000	.000	1.000	19.000	.000	.000	180.000	.000	.000	70.160	216.700	2.34E+18
24	19.000	19.400	.000	.400	19.400	.000	.000	180.000	.000	.000	62.705	216.700	2.10E+18
25	19.400	20.000	.000	.600	20.000	.000	.000	180.000	.000	.000	58.015	216.700	1.94E+18

TABLE B-2 (Cont.)

INTEGRATED ABSORBER AMOUNTS BY LAYER

I	LAYER BOUNDARIES FROM	TO	AIR	H20	CO2	O3	N2O	CO	CH4	O2
			INTEGRATED AMOUNTS (MOL CM-2)							
1	.000	1.000	2.426E+24	1.673E+22	8.014E+20	6.779E+16	7.772E+17	3.583E+17	4.129E+18	5.076E+23
2	1.000	1.500	1.127E+24	6.410E+21	3.723E+20	3.390E+16	3.610E+17	1.622E+17	1.918E+18	2.358E+23
3	1.500	2.000	1.073E+24	5.327E+21	3.542E+20	3.389E+16	3.435E+17	1.516E+17	1.825E+18	2.244E+23
4	2.000	3.000	1.990E+24	7.711E+21	6.570E+20	6.523E+16	6.370E+17	2.738E+17	3.384E+18	4.161E+23
5	3.000	4.000	1.795E+24	4.751E+21	5.926E+20	6.019E+16	5.747E+17	2.380E+17	3.053E+18	3.753E+23
6	4.000	4.500	8.293E+23	1.611E+21	2.738E+20	2.886E+16	2.655E+17	1.079E+17	1.411E+18	1.734E+23
7	4.500	5.000	7.862E+23	1.229E+21	2.596E+20	2.886E+16	2.518E+17	1.023E+17	1.337E+18	1.644E+23
8	5.000	6.000	1.450E+24	1.668E+21	4.788E+20	5.709E+16	4.643E+17	1.886E+17	2.467E+18	3.033E+23
9	6.000	7.000	1.298E+24	9.586E+20	4.287E+20	5.895E+16	4.157E+17	1.657E+17	2.208E+18	2.715E+23
10	7.000	7.500	5.960E+23	3.063E+20	1.969E+20	3.122E+16	1.909E+17	7.383E+16	1.013E+18	1.247E+23
11	7.500	8.000	5.626E+23	2.315E+20	1.858E+20	3.216E+16	1.802E+17	6.827E+16	9.559E+17	1.177E+23
12	8.000	9.000	1.031E+24	2.581E+20	3.405E+20	7.657E+16	3.299E+17	1.187E+17	1.749E+18	2.[illegible]56E+23
13	9.000	10.000	9.142E+23	9.979E+19	3.019E+20	1.006E+17	2.916E+17	9.609E+16	1.545E+18	1.[illegible]2E+23
14	10.000	10.600	4.968E+23	2.879E+19	1.641E+20	7.582E+16	1.575E+17	4.820E+16	8.363E+17	1.039E+23
15	10.600	11.000	3.111E+23	1.209E+19	1.027E+20	6.067E+16	9.799E+16	2.862E+16	5.220E+17	6.506E+22
16	11.000	12.000	7.020E+23	1.891E+19	2.318E+20	1.613E+17	2.190E+17	5.973E+16	1.172E+18	1.460E+23
17	12.000	13.000	6.001E+23	8.815E+18	1.982E+20	2.070E+17	1.845E+17	4.350E+16	9.931E+17	1.255E+23
18	13.000	14.000	5.120E+23	4.211E+18	1.694E+20	2.256E+17	1.552E+17	2.944E+16	8.394E+17	1.073E+23
19	14.000	15.000	4.383E+23	2.396E+18	1.447E+20	2.507E+17	1.303E+17	1.971E+16	7.086E+17	9.166E+22
20	15.000	16.000	3.746E+23	1.675E+18	1.237E+20	2.819E+17	1.091E+17	1.308E+16	5.974E+17	7.834E+22
21	16.000	17.000	3.202E+23	1.250E+18	1.057E+20	3.256E+17	9.072E+16	8.809E+15	5.024E+17	6.697E+22
22	17.000	18.000	2.738E+23	1.051E+18	9.040E+19	3.759E+17	7.473E+16	6.156E+15	4.211E+17	5.725E+22
23	18.000	19.000	2.340E+23	8.986E+17	7.728E+19	4.200E+17	6.089E+16	4.005E+15	3.515E+17	4.894E+22
24	19.000	19.400	8.381E+22	3.237E+17	2.767E+19	1.786E+17	2.092E+16	1.223E+15	1.232E+17	1.753E+22
25	19.400	20.000	1.163E+23	4.519E+17	3.839E+19	2.791E+17	2.807E+16	1.580E+15	1.676E+17	2.431E+22
TOTAL	.000	20.000	2.034E+25	4.737E+22	6.718E+21	3.538E+18	6.412E+18	2.369E+18	3.423E+19	4.255E+24

TABLE B-2 (Cont.)

```
SUMMARY OF THE GEOMETRY CALCULATION

      MODEL    =     U. S. STANDARD, 1976
      H1       =          .000 KM
      H2       =        20.000 KM
      ANGLE    =          .000 DEG
      RANGE    =        20.000 KM
      BETA     =          .000 DEG
      PHI      =       180.000 DEG
      HMIN     =          .000 KM
      BENDING  =          .000 DEG
      LEN      =            0
      AIRMAS   =     .945     RELATIVE TO A VERTICAL PATH , GROUND TO SPACE

FINAL SET OF LAYERS FOR INPUT TO FASCODE
A LAYER AMOUNT MAY BE SET TO ZERO IF THE CUMULATIVE AMOUNT FOR THAT LAYER AND ABOVE IS LESS THAN 0.1 PERCENT
OF THE TOTAL AMOUNT. THIS IS DONE ONLY FOR THE FOLLOWING CASES
    1.  IEMIT = 0 (TRANSMITTANCE)
    2.  IEMIT = 1 (RADIANCE) AND  IPATH = 3 (PATH LOOKING UP)

O2 IS NOT INCLUDED
IF THE AMOUNTS FOR ALL THE MOLECULES BUT O2 ARE ZEROED. THE REMAINING LAYERS ARE ELIMINATED
```

L	LAYER BOUNDARIES FROM (KM)	TO (KM)	IPATH	PBAR (MB)	TBAR (K)	INTEGRATED AMOUNTS (MOLS CM-2) AIR	H2O	CO2	O3	N2O	CO	CH4	O2
1	.000	1.500	3	929.14027	283.43	3.55E+24	2.31E+22	1.17E+21	1.02E+17	1.14E+18	5.20E+17	6.05E+18	7.43E+23
2	1.500	3.000	3	773.19998	273.69	3.06E+24	1.30E+22	1.01E+21	9.91E+16	9.81E+17	4.25E+17	5.21E+18	6.40E+23
3	3.000	4.500	3	639.19247	263.94	2.62E+24	6.36E+21	8.66E+20	8.91E+16	8.40E+17	3.46E+17	4.46E+18	5.49E+23
4	4.500	6.000	3	524.71482	254.20	2.24E+24	2.90E+21	7.38E+20	8.60E+16	7.16E+17	2.91E+17	3.80E+18	4.68E+23
5	6.000	7.500	3	427.48751	244.45	1.89E+24	1.26E+21	6.26E+20	9.02E+16	6.07E+17	2.40E+17	3.22E+18	3.96E+23
6	7.500	9.000	3	345.37569	234.71	1.59E+24	4.90E+20	5.26E+20	1.05E+17	5.10E+17	1.67E+17	2.70E+18	3.33E+23
7	9.000	10.600	3	274.71517	224.73	1.41E+24	1.29E+20	4.66E+20	1.76E+17	4.49E+17	1.44E+17	2.38E+18	2.95E+23
8	10.600	15.000	3	181.34791	216.88	2.56E+24	4.72E+19	8.47E+20	9.25E+17	7.87E+17	1.81E+17	4.24E+18	5.36E+23
9	15.000	19.400	3	90.91292	216.70	1.29E+24	5.20E+18	4.25E+20	1.58E+18	3.56E+17	3.34E+16	2.00E+18	2.69E+23
10	19.400	20.000	3	58.01539	216.70	1.16E+23	4.52E+17	3.84E+19	2.79E+17	2.81E+16	1.58E+15	1.60E+17	2.43E+22

I	NEW HEIGHT
1	.000
2	1.500
3	3.000
4	4.500
5	6.000
6	7.500

TABLE B-2 (Cont.)

TABLE B-2 (Cont.)

***** LOWTRAN 6 (MODIFIED)*****

LAYER ABSORBER AMOUNTS FOR THE PATH FROM Z(J) TO Z(J+1)

J	Z(J) (KM)	Z(J+1) (KM)	TBAR (K)	H2O LOWTRN U.	MOL SCAT	AER 1	AER 2	AER 3	AER 4	CIRRUS
1	.000	1.000	284.99	4.666E-01	9.031E-01	7.700E-01	.000E+00	.000E+00	.000E+00	.000E+00
2	1.000	1.500	280.08	1.679E-01	4.196E-01	2.075E-01	.000E+00	.000E+00	.000E+00	.000E+00
3	1.500	2.000	276.84	1.329E-01	3.595E-01	9.304E-02	.000E+00	.000E+00	.000E+00	.000E+00
4	2.000	3.000	271.99	1.764E-01	7.405E-01	3.105E-02	1.730E-02	.000E+00	.000E+00	.000E+00
5	3.000	4.000	265.49	9.803E-02	6.681E-01	.000E+00	2.572E-02	.000E+00	.000E+00	.000E+00
6	4.000	4.500	260.59	3.136E-02	3.099E-01	.000E+00	8.047E-03	.000E+00	.000E+00	.000E+00
7	4.500	5.000	257.34	2.274E-02	2.929E-01	.000E+00	5.727E-03	.000E+00	.000E+00	.000E+00
8	5.000	6.000	252.50	2.778E-02	5.398E-01	.000E+00	8.485E-03	.000E+00	.000E+00	.000E+00
9	6.000	7.000	245.00	1.429E-02	4.032E-01	.000E+00	6.944E-03	.000E+00	.000E+00	.000E+00
10	7.000	7.500	241.09	4.287E-03	2.220E-01	.000E+00	2.742E-03	.000E+00	.000E+00	.000E+00
11	7.500	8.000	237.84	3.067E-03	2.096E-01	.000E+00	2.021E-03	.000E+00	.000E+00	.000E+00
12	8.000	9.000	233.00	3.063E-03	3.837E-01	.000E+00	2.516E-03	.000E+00	.000E+00	.000E+00
13	9.000	10.000	226.55	1.050E-03	3.403E-01	.000E+00	1.454E-03	.000E+00	.000E+00	.000E+00
14	10.000	10.600	221.37	2.855E-04	1.851E-01	.000E+00	4.479E-04	1.438E-04	.000E+00	.000E+00
15	10.600	11.000	218.11	1.207E-04	1.159E-01	.000E+00	5.120E-05	2.557E-04	.000E+00	.000E+00
16	11.000	12.000	216.75	1.537E-04	2.613E-01	.000E+00	.000E+00	7.171E-04	.000E+00	.000E+00
17	12.000	13.000	216.70	6.216E-05	2.233E-01	.000E+00	.000E+00	5.768E-04	.000E+00	.000E+00
18	13.000	14.000	216.70	2.586E-05	1.909E-01	.000E+00	.000E+00	4.765E-04	.000E+00	.000E+00
19	14.000	15.000	216.72	1.268E-05	1.631E-01	.000E+00	.000E+00	4.181E-04	.000E+00	.000E+00
20	15.000	16.000	216.72	7.700E-06	1.394E-01	.000E+00	.000E+00	3.885E-04	.000E+00	.000E+00
21	16.000	17.000	216.70	4.979E-06	1.192E-01	.000E+00	.000E+00	4.035E-04	.000E+00	.000E+00
22	17.000	18.000	216.70	3.635E-06	1.019E-01	.000E+00	.000E+00	4.725E-04	.000E+00	.000E+00
23	18.000	19.000	216.70	2.697E-06	8.710E-02	.000E+00	.000E+00	5.585E-04	.000E+00	.000E+00
24	19.000	19.400	216.70	8.024E-07	3.124E-02	.000E+00	.000E+00	2.330E-04	.000E+00	.000E+00
25	19.400	20.000	216.70	1.149E-06	4.334E-02	.000E+00	.000E+00	3.520E-04	.000E+00	.000E+00

SUMMARY OF THE GEOMETRY CALCULATION

```
H1      =      .000 KM
H2      =    20.000 KM
ANGLE   =      .000 DEG
RANGE   =    20.000 KM
BETA    =      .000 DEG

PHI     =   180.000 DEG
HMIN    =      .000 KM
BENDING =      .000 DEG
LEN     =         0
```

EQUIVALENT SEA LEVEL TOTAL ABSORBER AMOUNTS

MOL SCAT	AER 1	AER 2	AER 3	AER 4	CIRRUS	MEAN RH

						(PRCNT)
7.573E+00	1.182E+00	8.149E-02	4.990E-03	.000E+00	.000E+00	48.24

FINAL LOWTRAN LAYERS

ZLO	ZHI	T	AER1	AER2	AER3	AER4	CIRRUS	RHRT	RNFTH
.000	1.500	283.33	1.057E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	1.500E+00
1.500	3.000	273.58	1.241E-01	1.730E-02	.000E+00	.000E+00	.000E+00	.000E+00	1.500E+00
3.000	4.500	263.83	.000E+00	3.376E-02	.000E+00	.000E+00	.000E+00	.000E+00	1.500E+00
4.500	6.000	254.08	.000E+00	1.421E-02	.000E+00	.000E+00	.000E+00	.000E+00	1.500E+00
6.000	7.500	244.33	.000E+00	9.686E-03	.000E+00	.000E+00	.000E+00	.000E+00	1.500E+00
7.500	9.000	234.58	.000E+00	4.537E-03	.000E+00	.000E+00	.000E+00	.000E+00	1.500E+00
9.000	10.600	224.55	.000E+00	1.981E-03	1.438E-04	.000E+00	.000E+00	.000E+00	1.600E+00
10.600	15.000	218.05	.000E+00	9.120E-05	2.446E-03	.000E+00	.000E+00	.000E+00	4.400E+00
15.000	19.400	216.70	.000E+00	.000E+00	2.048E-03	.000E+00	.000E+00	.000E+00	4.400E+00
19.400	20.000	216.70	.000E+00	.000E+00	3.520E-04	.000E+00	.000E+00	.000E+00	6.000E-01

LOWTRAN WAVENUMBER INTERVAL ** 890.000 920.000 5.000

FREQ	WAVELENGTH	TOTAL	RAIN
890.0	11.236	.8509	1.0000
895.0	11.173	.8496	1.0000
900.0	11.111	.8483	1.0000
905.0	11.050	.8470	1.0000
910.0	10.989	.8457	1.0000
915.0	10.929	.8441	1.0000
920.0	10.870	.8424	1.0000

INTEGRATED ABSORPTION FROM 890.000 TO 920.000 CM-1 = 4.59 CM-1
AVERAGE TRANSMITTANCE = .8469

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*****PROGRAM FSCATM*****     86/07/15.     16.05.06.


CONTROL CARD 2.1: MODEL AND OPTIONS

         MODEL    =      6
         ITYPE    =      2
         IBMAX    =     22
         NOZERO   =      1
         NOPRNT   =      0
         NMOL     =      7
         IPUNCH   =      0
         RE       =   6371.230 KM
         HSPACE   =    100.000 KM
         VBAR     =    905.000 CM-1


CONTROL CARD 2.1 PARAMETERS WITH DEFAULTS:

         MODEL    =      6
         ITYPE    =      2
         IBMAX    =     22
         NOZERO   =      1

         NOPRNT   =      0
         NMOL     =      7
         IPUNCH   =      0
         RE       =   6371.230 KM
         HSPACE   =    100.000 KM
         VBAR     =    905.000 CM-1


SLANT PATH SELECTED, ITYPE =     2


CONTROL CARD 2.2:  SLANT PATH PARAMETERS

         H1       =      .0000 KM
         H2       =    20.0000 KM
         ANGLE    =      .0000 DEG
         RANGE    =      .0000 KM
         BETA     =      .0000 DEG
         LEN      =          0
```

TABLE B-2 (Cont.)

ATMOSPHERIC PROFILE SELECTED IS: M = 6 U. S. STANDARD, 1976

I	Z (KM)	P (MB)	T (K)	REFRACT INDEX-1 *1.0E6	DENSITY (MOLS CM-3) AIR	H2O	CO2	O3	N2O	CO	CH4	O2
1	.000	1013.00000	288.20	271.94	2.55E+19	1.97E+17	8.41E+15	6.78E+11	8.15E+12	3.82E+12	4.33E+13	5.33E+18
2	1.000	898.80000	281.70	246.92	2.31E+19	1.40E+17	7.63E+15	6.78E+11	7.40E+12	3.35E+12	3.93E+13	4.83E+18
3	2.000	795.00000	275.20	223.62	2.09E+19	9.70E+16	6.91E+15	6.78E+11	6.70E+12	2.93E+12	3.56E+13	4.38E+18
4	3.000	701.20000	268.70	202.05	1.89E+19	6.02E+16	6.24E+15	6.27E+11	6.05E+12	2.55E+12	3.21E+13	3.95E+18
5	4.000	616.60000	262.20	182.11	1.70E+19	3.68E+16	5.62E+15	5.77E+11	5.45E+12	2.22E+12	2.90E+13	3.56E+18
6	5.000	540.50000	255.70	163.71	1.53E+19	2.14E+16	5.06E+15	5.77E+11	4.90E+12	1.99E+12	2.60E+13	3.20E+18
7	6.000	472.20000	249.20	146.76	1.37E+19	1.27E+16	4.53E+15	5.65E+11	4.39E+12	1.78E+12	2.33E+13	2.87E+18
8	7.000	411.10000	242.70	131.20	1.23E+19	7.02E+15	4.05E+15	6.15E+11	3.93E+12	1.54E+12	2.09E+13	2.57E+18
9	8.000	356.50000	236.20	116.91	1.09E+19	4.01E+15	3.61E+15	6.53E+11	3.50E+12	1.31E+12	1.86E+13	2.29E+18
10	9.000	308.00000	229.70	103.87	9.71E+18	1.54E+15	3.21E+15	8.91E+11	3.11E+12	1.07E+12	1.65E+13	2.03E+18
11	10.000	265.00000	223.30	91.93	8.60E+18	6.02E+14	2.84E+15	1.13E+12	2.73E+12	8.60E+11	1.45E+13	1.80E+18
12	11.000	227.00000	216.80	81.11	7.58E+18	2.74E+14	2.50E+15	1.63E+12	2.38E+12	6.83E+11	1.27E+13	1.59E+18
13	12.000	194.00000	216.70	69.35	6.48E+18	1.24E+14	2.14E+15	2.01E+12	2.01E+12	5.19E+11	1.08E+13	1.36E+18
14	13.000	165.80000	216.70	59.27	5.54E+18	5.02E+13	1.83E+15	2.13E+12	1.69E+12	3.60E+11	9.12E+12	1.16E+18
15	14.000	141.70000	216.70	50.65	4.74E+18	2.81E+13	1.56E+15	2.38E+12	1.42E+12	2.37E+11	7.71E+12	9.90E+17
16	15.000	121.10000	216.70	43.29	4.05E+18	2.03E+13	1.34E+15	2.63E+12	1.19E+12	1.62E+11	6.50E+12	8.46E+17
17	16.000	103.50000	216.70	37.00	3.46E+18	1.37E+13	1.14E+15	3.01E+12	9.96E+11	1.04E+11	5.48E+12	7.24E+17
18	17.000	88.50000	216.70	31.64	2.96E+18	1.14E+13	9.77E+14	3.51E+12	8.24E+11	7.40E+10	4.60E+12	6.19E+17
19	18.000	75.65000	216.70	27.04	2.53E+18	9.68E+12	8.35E+14	4.02E+12	6.76E+11	5.06E+10	3.85E+12	5.29E+17
20	19.000	64.67000	216.70	23.12	2.16E+18	8.33E+12	7.14E+14	4.39E+12	5.47E+11	3.24E+10	3.20E+12	4.52E+17
21	20.000	55.29000	216.70	19.76	1.85E+18	7.21E+12	6.10E+14	4.77E+12	4.37E+11	2.40E+10	2.63E+12	3.86E+17
22	21.000	47.29000	217.60	16.83	1.57E+18	6.26E+12	5.20E+14	4.77E+12	3.46E+11	1.89E+10	2.13E+12	3.29E+17
23	22.000	40.47000	218.60	14.34	1.34E+18	5.46E+12	4.43E+14	4.89E+12	2.75E+11	1.61E+10	1.71E+12	2.80E+17
24	23.000	34.67000	219.60	12.23	1.14E+18	4.80E+12	3.70E+14	4.77E+12	2.25E+11	1.49E+10	1.36E+12	2.39E+17
25	24.000	29.72000	220.60	10.44	9.76E+17	4.20E+12	3.22E+14	4.57E+12	1.83E+11	1.37E+10	1.09E+12	2.04E+17
26	25.000	25.49000	221.60	8.91	8.33E+17	3.69E+12	2.75E+14	4.27E+12	1.46E+11	1.33E+10	8.80E+11	1.74E+17
27	27.500	17.43000	224.00	6.03	5.64E+17	2.58E+12	1.86E+14	3.27E+12	8.96E+10	1.02E+10	5.57E+11	1.18E+17
28	30.000	11.97000	226.50	4.09	3.83E+17	1.81E+12	1.26E+14	2.51E+12	5.42E+10	7.66E+09	3.50E+11	8.00E+16
29	32.500	8.01000	230.00	2.70	2.52E+17	1.22E+12	8.33E+13	1.86E+12	2.94E+10	5.72E+09	2.09E+11	5.28E+16
30	35.000	5.74600	236.50	1.88	1.76E+17	8.63E+11	5.81E+13	1.39E+12	1.63E+10	4.49E+09	1.31E+11	3.68E+16
31	37.500	4.15000	242.90	1.32	1.24E+17	6.13E+11	4.09E+13	9.66E+11	8.29E+09	3.59E+09	8.19E+10	2.59E+16
32	40.000	2.87100	250.40	.89	8.30E+16	4.18E+11	2.74E+13	6.07E+11	3.75E+09	4.99E+09	4.69E+10	1.74E+16
33	42.500	2.06000	257.30	.62	5.80E+16	2.99E+11	1.91E+13	3.60E+11	1.69E+09	5.16E+09	2.68E+10	1.21E+16
34	45.000	1.49100	264.20	.44	4.09E+16	2.14E+11	1.35E+13	2.15E+11	6.51E+08	5.39E+09	1.49E+10	8.55E+15
35	47.500	1.09000	270.60	.31	2.92E+16	1.53E+11	9.64E+12	1.20E+11	2.74E+08	5.71E+09	8.10E+09	6.10E+15
36	50.000	.79780	270.70	.23	2.13E+16	1.12E+11	7.05E+12	6.62E+10	1.02E+08	6.19E+09	4.49E+09	4.46E+15
37	55.000	.42500	260.80	.13	1.18E+16	6.02E+10	3.90E+12	2.13E+10	2.23E+07	5.32E+09	1.95E+09	2.47E+15
38	60.000	.21900	247.00	.07	6.42E+15	3.05E+10	2.12E+12	7.07E+09	4.52E+06	4.50E+09	8.38E+08	1.34E+15
39	65.000	.10900	233.30	.04	3.38E+15	1.42E+10	1.12E+12	2.37E+09	8.54E+05	4.48E+09	3.50E+08	7.08E+14
40	70.000	.05220	219.60	.02	1.72E+15	6.03E+09	5.69E+11	5.17E+08	1.54E+05	4.31E+09	1.42E+08	3.60E+14
41	75.000	.02400	208.40	.01	8.34E+14	2.36E+09	2.75E+11	2.09E+08	2.62E+04	2.86E+09	5.49E+07	1.74E+14
42	80.000	.01050	198.60	.00	3.83E+14	7.86E+08	1.26E+11	1.15E+08	4.22E+03	1.80E+09	2.01E+07	8.01E+13
43	85.000	.00446	188.90	.00	1.71E+14	2.28E+08	5.65E+10	8.56E+07	6.60E+02	1.17E+09	7.18E+06	3.58E+13

TABLE B-2 (Cont.)

44	90.000	.00184	186.90	.00	7.13E+13	6.07E+07	2.35E+10	5.00E+07	9.64E+01	7.14E+08	2.40E+06	1.49E+13
45	95.000	.00076	188.40	.00	2.92E+13	1.58E+07	9.65E+09	2.05E+07	1.38E+01	3.00E+08	7.85E+05	6.00E+12
46	100.000	.00032	195.10	.00	1.19E+13	4.04E+06	3.92E+09	4.76E+06	1.97E+00	1.25E+08	2.55E+05	2.38E+12

CASE 2A: GIVEN H1, H2, ANGLE

SLANT PATH PARAMETERS IN STANDARD FORM

```
H1     =      .000 KM
H2     =    20.000 KM
ANGLE  =      .000 DEG
PHI    =   180.000 DEG
HMIN   =      .000 KM
LEN    =         0
```

HALFWIDTH INFORMATION ON THE USER SUPPLIED FASCODE BOUNDARIES
THE FOLLOWING VALUES ARE ASSUMED:

```
ALZERO   =    .100 CM-1  = AVERAGE LORENTZ WIDTH AT STP
AVMWT    =   36.00       = AVERAGE  MOLECULAR WEIGHT
VBAR     =  905.00  CM-1 = AVERAGE WAVENUMBER
```

I	Z (KM)	P (MB)	T (K)	LORENTZ (CM-1)	DOPPLER (CM-1)	ZETA	VOIGT (CM-1)	VOIGT RATIO	TEMP DIFF (K)
1	.000	1013.00000	288.20	.10132	.00092	.991	.10133	1.10	9.8
2	1.500	845.30823	278.45	.08601	.00090	.990	.08602	1.18	9.8
3	3.000	701.20000	268.70	.07263	.00089	.988	.07264	1.19	9.8
4	4.500	577.29741	258.95	.06091	.00087	.986	.06093	1.20	9.8
5	6.000	472.20000	249.20	.05079	.00085	.983	.05080	1.21	9.8
6	7.500	382.82783	239.45	.04201	.00084	.980	.04202	1.22	9.8
7	9.000	308.00000	229.70	.03451	.00082	.977	.03453	1.25	10.3
8	10.600	241.49818	219.40	.02768	.00080	.972	.02771	1.98	2.7
9	15.000	121.10000	216.70	.01397	.00080	.946	.01401	1.98	.0
10	19.400	60.74078	216.70	.00701	.00080	.898	.00710	1.98	3.9
11	24.000	29.72000	220.60	.00340	.00080	.809	.00358	2.01	5.6
12	29.700	12.52214	226.20	.00141	.00081	.635	.00178	1.50	11.1
13	35.300	5.52596	237.27	.00061	.00083	.423	.00119	1.15	11.3
14	39.400	3.13644	248.60	.00034	.00085	.284	.00104	1.07	11.5
15	43.500	1.81014	260.06	.00019	.00087	.180	.00097	1.09	1.2
16	55.700	.38733	258.87	.00004	.00087	.045	.00089	1.04	12.4
17	60.200	.21297	246.45	.00002	.00085	.026	.00086	1.03	12.6
18	64.800	.11208	233.85	.00001	.00083	.015	.00083	1.03	12.9
19	69.500	.05619	220.97	.00001	.00080	.008	.00081	1.03	13.2
20	75.300	.02284	207.81	.00000	.00078	.003	.00078	1.04	13.5
21	82.200	.00720	194.33	.00000	.00075	.001	.00075	1.00	.8
22	100.000	.00032	195.10	.00000	.00075	.000	.00075	.00	.0

TABLE B-2 (Cont.)

CALCULATION OF THE REFRACTED PATH THROUGH THE ATMOSPHERE

I	ALTITUDE FROM (KM)	ALTITUDE TO (KM)	THETA (DEG)	DRANGE (KM)	RANGE (KM)	DBETA (DEG)	BETA (DEG)	PHI (DEG)	DBEND (DEG)	BENDING (DEG)	PBAR (MB)	TBAR (K)	RHOBAR (MOL CM-3)
	H1 TO H2												
1	.000	1.000	.000	1.000	1.000	.000	.000	180.000	.000	.000	955.683	284.990	2.43E+19
2	1.000	1.500	.000	.500	1.500	.000	.000	180.000	.000	.000	872.002	280.085	2.25E+19
3	1.500	2.000	.000	.500	2.000	.000	.000	180.000	.000	.000	820.105	276.835	2.15E+19
4	2.000	3.000	.000	1.000	3.000	.000	.000	180.000	.000	.000	747.913	271.992	1.99E+19
5	3.000	4.000	.000	1.000	4.000	.000	.000	180.000	.000	.000	658.727	265.493	1.80E+19
6	4.000	4.500	.000	.500	4.500	.000	.000	180.000	.000	.000	596.908	260.586	1.66E+19
7	4.500	5.000	.000	.500	5.000	.000	.000	180.000	.000	.000	558.860	257.336	1.57E+19
8	5.000	6.000	.000	1.000	6.000	.000	.000	180.000	.000	.000	506.204	252.495	1.45E+19
9	6.000	7.000	.000	1.000	7.000	.000	.000	180.000	.000	.000	441.516	245.996	1.30E+19
10	7.000	7.500	.000	.500	7.500	.000	.000	180.000	.000	.000	396.932	241.087	1.19E+19
11	7.500	8.000	.000	.500	8.000	.000	.000	180.000	.000	.000	369.634	237.837	1.13E+19
12	8.000	9.000	.000	1.000	9.000	.000	.000	180.000	.000	.000	332.137	232.999	1.03E+19
13	9.000	10.000	.000	1.000	10.000	.000	.000	180.000	.000	.000	286.399	226.550	9.14E-18
14	10.000	10.600	.000	.600	10.600	.000	.000	180.000	.000	.000	253.215	221.369	8.28E+18
15	10.600	11.000	.000	.400	11.000	.000	.000	180.000	.000	.000	234.235	218.189	7.78E+18
16	11.000	12.000	.000	1.000	12.000	.000	.000	180.000	.000	.000	210.499	216.751	7.02E+18
17	12.000	13.000	.000	1.000	13.000	.000	.000	180.000	.000	.000	179.900	216.700	6.00E+18
18	13.000	14.000	.000	1.000	14.000	.000	.000	180.000	.000	.000	153.750	216.700	5.13E+18
19	14.000	15.000	.000	1.000	15.000	.000	.000	180.000	.000	.000	131.400	216.700	4.38E+18
20	15.000	16.000	.000	1.000	16.000	.000	.000	180.000	.000	.000	112.300	216.700	3.75E+18
21	16.000	17.000	.000	1.000	17.000	.000	.000	180.000	.000	.000	96.000	216.700	3.20E+18
22	17.000	18.000	.000	1.000	18.000	.000	.000	180.000	.000	.000	82.075	216.700	2.74E+18
23	18.000	19.000	.000	1.000	19.000	.000	.000	180.000	.000	.000	70.160	216.700	2.34E+18
24	19.000	19.400	.000	.400	19.400	.000	.000	180.000	.000	.000	62.705	216.700	2.10E+18
25	19.400	20.000	.000	.600	20.000	.000	.000	180.000	.000	.000	58.015	216.700	1.94E+18

INTEGRATED ABSORBER AMOUNTS BY LAYER

I	LAYER BOUNDARIES FROM	TO	INTEGRATED AMOUNTS (MOL CM-2) AIR	H2O	CO2	O3	N2O	CO	CH4	O2
1	.000	1.000	2.426E+24	1.673E+22	8.014E+20	6.779E+16	7.772E+17	3.583E+17	4.129E+18	5.076E+23
2	1.000	1.500	1.127E+24	6.410E+21	3.723E+20	3.390E+16	3.610E+17	1.622E+17	1.918E+18	2.358E+23
3	1.500	2.000	1.073E+24	5.327E+21	3.542E+20	3.389E+16	3.435E+17	1.516E+17	1.825E+18	2.244E+23
4	2.000	3.000	1.990E+24	7.711E+21	6.570E+20	6.523E+16	6.370E+17	2.738E+17	3.384E+18	4.161E+23
5	3.000	4.000	1.795E+24	4.751E+21	5.926E+20	6.019E+16	5.747E+17	2.380E+17	3.053E+18	3.753E+23
6	4.000	4.500	8.293E+23	1.611E+21	2.738E+20	2.886E+16	2.655E+17	1.079E+17	1.411E+18	1.734E+23
7	4.500	5.000	7.862E+23	1.229E+21	2.596E+20	2.886E+16	2.518E+17	1.023E+17	1.337E+18	1.644E+23
8	5.000	6.000	1.450E+24	1.668E+21	4.788E+20	5.709E+16	4.643E+17	1.886E+17	2.467E+18	3.033E+23
9	6.000	7.000	1.298E+24	9.586E+20	4.287E+20	5.895E+16	4.157E+17	1.657E+17	2.208E+18	2.715E+23
10	7.000	7.500	5.960E+23	3.063E+20	1.969E+20	3.122E+16	1.909E+17	7.383E+16	1.013E+18	1.247E+23
11	7.500	8.000	5.626E+23	2.315E+20	1.858E+20	3.216E+16	1.802E+17	6.827E+16	9.559E+17	1.177E+23
12	8.000	9.000	1.031E+24	2.581E+20	3.405E+20	7.657E+16	3.299E-17	1.187E+17	1.749E+18	2.156E+23
13	9.000	10.000	9.142E+23	9.979E+19	3.019E+20	1.006E+17	2.916E+17	9.609E+16	1.545E+18	1.912E+23
14	10.000	10.600	4.960E+23	2.879E+19	1.641E+20	7.582E+16	1.575E+17	4.820E+16	8.363E+17	1.039E+23
15	10.600	11.000	3.111E+23	1.289E+19	1.027E+20	6.067E+16	9.799E+16	2.862E+16	5.220E+17	6.506E+22
16	11.000	12.000	7.020E+23	1.891E+19	2.318E+20	1.813E+17	2.190E+17	5.973E+16	1.172E+18	1.468E+23
17	12.000	13.000	6.001E+23	8.815E+18	1.982E+20	2.070E+17	1.845E+17	4.350E+16	9.931E+17	1.255E+23
18	13.000	14.000	5.128E+23	4.211E+18	1.694E+20	2.256E+17	1.552E+17	2.944E+16	8.394E+17	1.073E+23
19	14.000	15.000	4.383E+23	2.396E+18	1.447E+20	2.507E+17	1.303E+17	1.971E+16	7.086E+17	9.166E+22
20	15.000	16.000	3.746E+23	1.675E+18	1.237E+20	2.819E+17	1.091E+17	1.308E+16	5.974E+17	7.834E+22
21	16.000	17.000	3.202E+23	1.250E+18	1.057E+20	3.256E+17	9.072E+16	8.809E+15	5.024E+17	6.697E+22
22	17.000	18.000	2.738E+23	1.051E+18	9.040E+19	3.759E+17	7.473E+16	6.156E+15	4.211E+17	5.725E+22
23	18.000	19.000	2.340E+23	8.986E+17	7.728E+19	4.200E+17	6.089E+16	4.085E+15	3.515E+17	4.894E+22
24	19.000	19.400	8.381E+22	3.237E+17	2.767E+19	1.786E+17	2.092E+16	1.223E+15	1.232E+17	1.753E+22
25	19.400	20.000	1.163E+23	4.519E+17	3.839E+19	2.791E+17	2.807E+16	1.580E+15	1.676E+17	2.431E+22
TOTAL	.000	20.000	2.034E+25	4.737E+22	6.718E+21	3.538E+18	6.412E+18	2.369E+18	3.423E+19	4.255E+24

TABLE B-2 (Cont.)

SUMMARY OF THE GEOMETRY CALCULATION

```
MODEL    =     U. S. STANDARD, 1976
H1       =        .000 KM
H2       =      20.000 KM
ANGLE    =        .000 DEG
RANGE    =      20.000 KM
BETA     =        .000 DEG
PHI      =     180.000 DEG
HMIN     =        .000 KM
BENDING  =        .000 DEG
LEN      =           0
AIRMAS   =    .945     RELATIVE TO A VERTICAL PATH , GROUND TO SPACE
```

FINAL SET OF LAYERS FOR INPUT TO FASCODE
A LAYER AMOUNT MAY BE SET TO ZERO IF THE CUMULATIVE AMOUNT FOR THAT LAYER AND ABOVE IS LESS THAN 0.1 PERCENT OF THE TOTAL AMOUNT. THIS IS DONE ONLY FOR THE FOLLOWING CASES
1. IEMIT = 0 (TRANSMITTANCE)
2. IEMIT = 1 (RADIANCE) AND IPATH = 3 (PATH LOOKING UP)

O2 IS NOT INCLUDED
IF THE AMOUNTS FOR ALL THE MOLECULES BUT O2 ARE ZEROED. THE REMAINING LAYERS ARE ELIMINATED

L	LAYER BOUNDARIES FROM (KM)	TO (KM)	IPATH	PBAR (MB)	TBAR (K)	INTEGRATED AMOUNTS (MOLS CM-2) AIR	H2O	CO2	O3	N2O	CO	CH4	O2
1	.000	1.500	3	929.14827	283.43	3.55E+24	2.31E+22	1.17E+21	1.02E+17	1.14E+18	5.20E+17	6.05E+18	7.43E+23
2	1.500	3.000	3	773.19998	273.69	3.06E+24	1.30E+22	1.01E+21	9.91E+16	9.81E+17	4.25E+17	5.21E+18	6.40E+23
3	3.000	4.500	3	639.19247	263.94	2.62E+24	6.36E+21	8.66E+20	8.91E+16	8.40E+17	3.46E+17	4.46E+18	5.49E+23
4	4.500	6.000	3	524.71482	254.20	2.24E+24	2.90E+21	7.38E+20	8.60E+16	7.16E+17	2.91E+17	3.80E+18	4.68E+23
5	6.000	7.500	3	427.48751	244.45	1.89E+24	1.26E+21	6.26E+20	9.02E+16	6.07E+17	2.40E+17	3.22E+18	3.96E+23
6	7.500	9.000	3	345.37569	234.71	1.59E+24	4.90E+20	5.26E+20	1.09E+17	5.10E+17	1.87E+17	2.70E+18	3.33E+23
7	9.000	10.600	3	274.71517	224.73	1.41E+24	1.29E+20	4.66E+20	1.76E+17	4.49E+17	1.44E+17	2.38E+18	2.95E+23
8	10.600	15.000	3	181.34791	216.88	2.56E+24	4.72E+19	8.47E+20	9.25E+17	7.87E+17	1.81E+17	4.24E+18	5.36E+23
9	15.000	19.400	3	90.91292	216.70	1.29E+24	5.20E+18	4.25E+20	1.58E+18	3.56E+17	3.34E+16	2.00E+18	2.69E+23
10	19.400	20.000	3	59.81539	216.70	1.16E+23	4.52E+17	3.84E+19	2.79E+17	2.81E+16	1.58E+15	1.68E+17	2.43E+22

TABLE B-2 (Cont.)

V1(CM-1) = 9ØØ.ØØØØ
V2(CM-1) = 91Ø.ØØØØ
SAMPLE = 4.ØØØØ
DVSET = .ØØØØØØ
ALFALØ = .1ØØØ
AVMASS = 36.ØØØØ
DPTMIN = .ØØØØE+ØØ   DPTFAC = .ØØØØØØ
TBOUND = .ØØØØ   BOUNDARY EMISSIVITY = 1.ØØØØØ

SECANT = 1.ØØØØ

AER TEST CASE - MULTIPLE SCATTERING - RURAL AEROSOL * 9ØØ - 91Ø CM-1   FASCOD2   86/Ø7/15 16.Ø4.54

LAYER		P(MB)	T(K)	ALPHL	ALPHD	ALPHV	ZETA	CALC DV	H2OSLF	DV	TYPE	ITYPE	IPATH	SECANT
1	.ØØ TO 1.5Ø KM	929.14Ø3	283.43	.Ø96174	.ØØØ9Ø9	.Ø96183	.991	.Ø24Ø46	1.Ø26Ø	.Ø24ØØØ	.ØØØ	99	3	1.ØØØØØØ
2	1.5Ø TO 3.ØØ KM	773.2ØØØ	273.69	.Ø8Ø73Ø	.ØØØ894	.Ø8Ø74Ø	.989	.Ø2Ø185	1.Ø17Ø	.Ø24ØØØ	1.189	Ø	3	1.ØØØØØØ
3	3.ØØ TO 4.5Ø KM	639.1925	263.94	.Ø67469	.ØØØ878	.Ø67480	.987	.Ø1687Ø	1.ØØ97	.Ø16ØØØ	1.423	2	3	1.ØØØØØØ
4	4.5Ø TO 6.ØØ KM	524.7148	254.2Ø	.Ø56185	.ØØØ861	.Ø5619Ø	.985	.Ø14Ø49	1.ØØ52	.Ø16ØØØ	1.139	Ø	3	1.ØØØØØØ
5	6.ØØ TO 7.5Ø KM	427.4875	244.45	.Ø46561	.ØØØ845	.Ø46576	.982	.Ø11644	1.ØØ27	.Ø1Ø667	1.374	2	3	1.ØØØØØØ
6	7.5Ø TO 9.ØØ KM	345.3757	234.71	.Ø38335	.ØØØ828	.Ø38353	.979	.ØØ9588	1.ØØ12	.Ø1Ø667	1.112	Ø	3	1.ØØØØØØ
7	9.ØØ TO 1Ø.69 KM	274.7152	224.73	.Ø31135	.ØØØ81Ø	.Ø31156	.975	.ØØ7789	1.ØØØ4	.ØØ7111	1.369	2	3	1.ØØØØØØ
8	1Ø.69 TO 15.ØØ KM	181.3479	216.88	.Ø2Ø915	.ØØØ795	.Ø2Ø946	.963	.ØØ5236	1.ØØØ1	.ØØ4741	1.358	2	3	1.ØØØØØØ
9	15.ØØ TO 19.4Ø KM	9Ø.9129	216.7Ø	.Ø1Ø489	.ØØØ795	.Ø1Ø549	.93Ø	.ØØ2637	1.ØØØØ	.ØØ237Ø	1.798	1	3	1.ØØØØØØ
1Ø	19.4Ø TO 2Ø.ØØ KM	58.Ø154	216.7Ø	.ØØ6694	.ØØØ795	.ØØ6787	.894	.ØØ1697	1.ØØØØ	.ØØ158Ø	1.397	2	3	1.ØØØØØØ

TABLE B-2 (Cont.)

AER TEST CASE - MULTIPLE SCATTERING - RURAL AEROSOL * 900 - 910 CM-1   FASCOD2   86/07/15 16.04.54

MOLECULAR AMOUNTS (MOL/CM**2) BY LAYER

		P(MB)	T(K)	IPATH	H2O	CO2	O3	N2O	CO	CH4	O2	OTHER
1	.00 TO 1.50 KM	929.14027	283.43	3	2.314E+22	1.174E+21	1.017E+17	1.138E+18	5.205E+17	6.047E+18	7.434E+23	2.786E+24
2	1.50 TO 3.00 KM	773.19998	273.69	3	1.304E+22	1.011E+21	9.912E+16	9.806E+17	4.254E+17	5.209E+18	6.404E+23	2.408E+24
3	3.00 TO 4.50 KM	639.19247	263.94	3	6.362E+21	8.665E+20	8.905E+16	8.402E+17	3.459E+17	4.464E+18	5.488E+23	2.068E+24
4	4.50 TO 6.00 KM	524.71482	254.20	3	2.897E+21	7.385E+20	8.595E+16	7.161E+17	2.909E+17	3.804E+18	4.677E+23	1.765E+24
5	6.00 TO 7.50 KM	427.48751	244.45	3	1.265E+21	6.256E+20	9.016E+16	6.066E+17	2.395E+17	3.221E+18	3.962E+23	1.496E+24
6	7.50 TO 9.00 KM	345.37569	234.71	3	4.895E+20	5.263E+20	1.087E+17	5.101E+17	1.870E+17	2.705E+18	3.333E+23	1.259E+24
7	9.00 TO 10.50 KM	274.71517	224.73	3	1.285E+20	4.660E+20	1.764E+17	4.491E+17	1.443E+17	2.382E+18	2.951E+23	1.115E+24
8	10.50 TO 15.00 KM	181.34791	216.88	3	4.721E+19	8.469E+20	9.253E+17	7.070E+17	1.810E+17	4.235E+18	5.363E+23	2.027E+24
9	15.00 TO 19.40 KM	90.91292	216.70	3	5.198E+18	4.249E+20	1.582E+16	3.564E+17	3.335E+16	1.996E+18	2.690E+23	1.017E+24
10	19.40 TO 20.00 KM	58.01539	216.70	3	4.519E+17	3.839E+19	2.791E+17	2.807E+16	1.580E+15	1.576E+17	2.431E+22	9.191E+22
	ACCUMLATED MOLECULAR AMOUNTS FOR TOTAL PATH											
10	.00 TO 20.00 KM	533.71191	251.73		4.737E+22	6.710E+21	3.538E+18	6.412E+18	2.369E+18	3.423E+19	4.255E+24	1.603E+25

LINE FILE INFORMATION

LINE FILE FOR FASCOD2 PKG FOR 800 - 1199 CM-1   BCDMRG2   86/03/25 12.55.52

H2O	=	814	2.0370E-24
CO2	=	2008	2.0872E-24
O3	=	19025	1.4911E-20
N2O	=	721	4.0078E-22
CO	=	0	.0000E+00
CH4	=	226	9.7269E-24
O2	=	0	.0000E+00

LOWEST LINE = 800.000   HIGHEST LINE = 1199.985   TOTAL NUMBER OF LINES = 22794

TABLE B-2 (Cont.)

```
AER TEST CASE - MULTIPLE SCATTERING - RURAL AEROSOL * 900 - 910 CM-1    FASCOD2   86/07/15  16.04.54

LAYER =         1

**************  CONTINUA: H2O(T),CO2,N2  (01 JULY 82)
                          O2(1600CM-1), O3(DIFFUSE,T), H2O SELF HAS BEEN REDUCED IN THE 800-1200 CM-1 REGION  (01 SEPT 1985)

      LBLF4 *
DV FOR LBLF4 =     1.53600    BOUND FOR LBLF4 =    25.0000

N0. LINES BEFORE SHRINK =      659.  NO. LINES AFTER SHRINK =      148.  NO. LINES AFTER REJECT =     144

        TIME             READ    CONVOLUTION          PANEL
      72.612             .026           .930           .001

      HIRAC1
OUTPUT ON FILE    10           DV =   .02400000            BOUNDF3(CM-1) =   6.1440

LOCATION  WAVENUMBER  OPT. DEPTH                                  LOCATION   WAVENUMBER   OPT. DEPTH

  1025     900.000000  .43862368E-01                                1438     909.912000  .52997347E-01
  1026     900.024000  .43873529E-01                                1439     909.936000  .52234962E-01
  1027     900.048000  .43887106E-01                                1440     909.960000  .51996562E-01
  1028     900.072000  .43903231E-01                                1441     909.984000  .52289134E-01
  1029     900.096000  .43923428E-01                                1442     910.000000  .53101751E-01

        TIME             READ    CONVOLUTION          PANEL
      72.758             .014           .005           .007

-------------------------  14 HALF WIDTH CHANGES

AVERAGE WIDTH =  .062977,  AVERAGE ZETA =  .982264, NO. LINES =     321, NO. LINES AFTER REJECT =   321, NO. HW CHANGES =   14


AER TEST CASE - MULTIPLE SCATTERING - RURAL AEROSOL * 900 - 910 CM-1    FASCOD2   86/07/15  16.04.54

TIME AT THE START OF --EMINIT--      72.770

INITIAL LAYER    1  FINAL LAYER     1

FILE    25 MERGED WITH FILE    10 ONTO FILE   23  WITH XTYPE=    0.

INITIAL LAYER    1  FINAL LAYER     1

FILE    10 MERGED WITH FILE    11 ONTO FILE

LOCATION  WAVENUMBER  RADIANCE       TRANSMITTANCE                LOCATION   WAVENUMBER   RADIANCE       TRANSMITTANCE

    1      900.000000  .61784845E-06  .88602463E+00                  414     909.912000  .68365738E-06  .87680000E+00
    2      900.024000  .61794864E-06  .88601474E+00                  415     909.936000  .67752379E-06  .87746871E+00
    3      900.048000  .61805285E-06  .88600271E+00                  416     909.960000  .67560485E-06  .87767792E+00

    4      936.072000  .61818611E-06  .88598842E+00                  417     909.984000  .67795977E-06  .87742118E+00
    5      900.096000  .61835301E-06  .88597053E+00                  418     910.000000  .68456245E-06  .87668722E+00

LOCATION  WAVENUMBER  COMP FLUX UP   COMP REFLECT UP              LOCATION   WAVENUMBER   COMP FLUX UP   COMP REFLECT UP
```

TABLE B-2 (Cont.)

```
    1    900.000000  .30178013E-04  .12929804E-01          414    909.912000  .29646476E-04  .13082286E-01
    2    900.024000  .30177982E-04  .12929646E-01          415    909.936000  .29648566E-04  .13098646E-01
    3    900.048000  .30177944E-04  .12929356E-01          416    909.960000  .29649220E-04  .13103777E-01

    4    900.072000  .30177899E-04  .12929012E-01          417    909.984000  .29648417E-04  .13097480E-01
    5    900.096000  .30177842E-04  .12928500E-01          418    910.000000  .29645910E-04  .13088241E-01
 TIME REQUIRED FOR -- EMINIT--          .067


 AER TEST CASE - MULTIPLE SCATTERING - RURAL AEROSOL * 900 - 910 CM-1    FASCOD2   86/07/15  16.04.54

 LAYER =        2

************** CONTINUA: H2O(T),CO2,N2  (01 JULY 82)
                        O2(1600CM-1), O3(DIFFUSE,T), H2O SELF HAS BEEN REDUCED IN THE 800-1200 CM-1 REGION  (01 SEPT 1985)

      LBLF4 *
DV FOR LBLF4 =    1.53600     BOUND FOR LBLF4 =   25.0000

 NO. LINES BEFORE SHRINK =      659.  NO. LINES AFTER SHRINK =      148.  NO. LINES AFTER REJECT =     144

        TIME             READ    CONVOLUTION          PANEL
      72.932             .026          .032            .000

      HIRAC1
OUTPUT ON FILE    10            DV =     .02400000           BOUNDF3(CM-1) =    6.1440

 LOCATION  WAVENUMBER  OPT. DEPTH                                   LOCATION   WAVENUMBER  OPT. DEPTH

   1025    900.000000  .17204370E-01                                  1438    909.912000  .20542306E-01
   1026    900.024000  .17209253E-01                                  1439    909.936000  .20243310E-01

   1027    900.048000  .17216103E-01                                  1440    909.960000  .20223959E-01
   1028    900.072000  .17226114E-01                                  1441    909.984000  .20501043E-01
   1029    900.096000  .17239097E-01                                  1442    910.000000  .20920112E-01

        TIME             READ    CONVOLUTION          PANEL
      73.052             .013          .074            .007
-------------------------  17 HALF WIDTH CHANGES
 AVERAGE WIDTH =  .053895.  AVERAGE ZETA =  .979547. NO. LINES =   321. NO. LINES AFTER REJECT =   321. NO. HW CHANGES =   17


 AER TEST CASE - MULTIPLE SCATTERING - RURAL AEROSOL * 900 - 910 CM-1    FASCOD2   86/07/15  16.04.54

 THE TIME AT THE START OF RADMRG IS        73.066

 INITIAL LAYER    1  FINAL LAYER    2

 FILE    10 MERGED WITH FILE     11 ONTO FILE    12
CNTRL AND IANT     3    0

 LOCATION  WAVENUMBER  RADIANCE       TRANSMITTANCE              LOCATION  WAVENUMBER  RADIANCE       TRANSMITTANCE

      1    900.000000  .75756068E-06  .86289760E+00                414    909.912000  .84112338E-06  .85093451E+00
      2    900.024000  .75768397E-06  .86288375E+00                415    909.936000  .83317599E-06  .85183822E+00

      3    900.048000  .75784003E-06  .86286613E+00                416    909.960000  .83115899E-06  .85205781E+00
      4    900.072000  .75803789E-06  .86284358E+00                417    909.984000  .83527004E-06  .85157257E+00
      5    900.096000  .75828068E-06  .86281495E+00                418    910.000000  .84445302E-06  .85050170E+00

 LOCATION  WAVENUMBER  COMP FLUX UP   COMP REFLECT UP            LOCATION  WAVENUMBER  COMP FLUX UP   COMP REFLECT UP

      1    900.000000  .30010006E-04  .13672841E-01                414    909.912000  .29462067E-04  .13709414E-01
```

TABLE B-2 (Cont.)

```
   2     900.024000   .30019749E-04   .13672403E-01
   3     900.040000   .30010675E-04   .13671030E-01
   4     900.072000   .30010576E-04   .13671066E-01
   5     900.096000   .30010449E-04   .13670090E-01

THE TIME AT THE END OF RADMRG IS        73.130
     .072 SECS WERE REQUIRED FOR THIS MERGE

AER TEST CASE - MULTIPLE SCATTERING - RURAL AEROSOL * 900 - 910 CM-1    FASCOD2   86/07/15  16.04.54

LAYER =        3

************** CONTINUA: H2O(T),CO2,N2  (01 JULY 82)
                        O2(1600CM-1), O3(DIFFUSE,T), H2O SELF HAS BEEN REDUCED IN THE 800-1200 CM-1 REGION  (01 SEPT 1985)

     LBLF4 *
DV FOR LBLF4 =     1.02400      BOUND FOR LBLF4 =    25.0000

N0. LINES BEFORE SHRINK =       647.  NO. LINES AFTER SHRINK =      189.  NO. LINES AFTER REJECT =      179

        TIME              READ      CONVOLUTION          PANEL
      73.250              .027           .039             .001

      HIRAC1
OUTPUT ON FILE    10             DV =      .01600000          BOUNDF3(CM-1) =   4.0960

LOCATION  WAVENUMBER   OPT. DEPTH

  1025     900.000000   .50995146E-02
  1026     900.016000   .51005661E-02
  1027     900.032000   .51021075E-02
  1028     900.048000   .51045525E-02
  1029     900.064000   .51001610E-02

        TIME              READ      CONVOLUTION          PANEL
      73.364              .014           .070             .000
------------------------  11 HALF WIDTH CHANGES

AVERAGE WIDTH =  .045278,  AVERAGE ZETA =  .975949, NO. LINES =    248, NO. LINES AFTER REJECT =   248, NO. HW CHANGES =    11

AER TEST CASE - MULTIPLE SCATTERING - RURAL AEROSOL * 900 - 910 CM-1    FASCOD2   86/07/15  16.04.54

THE TIME AT THE START OF RADMRG IS        73.379

INITIAL LAYER    1  FINAL LAYER    3

FILE    10 MERGED WITH FILE     12 ONTO FILE    11
CNTRL AND IANT     3     0

LOCATION  WAVENUMBER   RADIANCE         TRANSMITTANCE
     1    900.000000   .78793664E-06   .65818816E+00

     2    900.016000   .78801628E-06   .85817899E+00
     3    900.032000   .78812156E-06   .85816679E+00
     4    900.048000   .78824286E-06   .85815253E+00

     5    900.064000   .78838896E-06   .85813510E+00

LOCATION  WAVENUMBER   COMP FLUX UP    COMP REFLECT UP

 415     909.936000   .29465700E-04   .13737762E-01

 416     909.960000   .29466437E-04   .13743334E-01
 417     909.984000   .29464165E-04   .13725211E-01
 418     910.000000   .29459463E-04   .13698995E-01

LOCATION  WAVENUMBER   OPT. DEPTH

 1646     909.936000   .61512844E-02
 1647     909.952000   .61467615E-02
 1648     909.968000   .62111438E-02
 1649     909.984000   .63469370E-02
 1650     910.000000   .65153316E-02

LOCATION  WAVENUMBER   RADIANCE         TRANSMITTANCE
  622     909.936000   .86817319E-06   .84629824E+00

  623     909.952000   .86614973E-06   .84652430E+00
  624     909.968000   .86723157E-06   .84637700E+00
  625     909.984000   .87587384E-06   .84533696E+00

  626     910.000000   .87677560E-06   .84519462E+00

LOCATION  WAVENUMBER   COMP FLUX UP    COMP REFLECT UP
```

```
  1   900.000000  .29963208E-04  .13429722E-01        622   909.936000  .29409933E-04  .13445045E-01

  2   900.016000  .29963245E-04  .13429416E-01        623   909.952000  .29418783E-04  .13451417E-01
  3   900.032000  .29963187E-04  .13429001E-01        624   909.968000  .29409700E-04  .13443620E-01
  4   900.048000  .29963114E-04  .13428495E-01        625   909.984000  .29404427E-04  .13410878E-01

  5   900.064000  .29963020E-04  .13427850E-01        626   910.000000  .29403022E-04  .13403054E-01
THE TIME AT THE END OF RADMRG IS          73.483
     .104 SECS WERE REQUIRED FOR THIS MERGE




AER TEST CASE - MULTIPLE SCATTERING - RURAL AEROSOL * 900 - 910 CM-1    FASCOD2    86/07/15  16.04.54

LAYER =          4
**************  CONTINUA: H2O(T),CO2,N2  (01 JULY 82)
                                  O2(1600CM-1), O3(DIFFUSE,T), H2O SELF HAS BEEN REDUCED IN THE 800-1200 CM-1 REGION  (01 SEPT 1985)

      LBLF4 *
DV FOR LBLF4 =     1.02400      BOUND FOR LBLF4 =    25.0000
N0. LINES BEFORE SHRINK =       647.  NO. LINES AFTER SHRINK =      189.  NO. LINES AFTER REJECT =       179

       TIME              READ    CONVOLUTION         PANEL
      73.599             .026           .039          .008

      HIRAC1
OUTPUT ON FILE    10            DV =      .01600000          BOUNDF3(CM-1) =    4.0960
 LOCATION  WAVENUMBER  OPT. DEPTH                                   LOCATION   WAVENUMBER  OPT. DEPTH

   1025    900.000000  .13332791E-02                                  1646     909.936000  .16636445E-02
   1026    900.016000  .13333825E-02                                  1647     909.952000  .16744265E-02

   1027    900.032000  .13338344E-02                                  1648     909.968000  .17201954E-02
   1028    900.048000  .13350451E-02                                  1649     909.984000  .18063762E-02
   1029    900.064000  .13369103E-02                                  1650     910.000000  .19391071E-02

       TIME              READ    CONVOLUTION         PANEL
      73.709             .015           .061          .009
-------------------------  15 HALF WIDTH CHANGES
AVERAGE WIDTH =  .038333,  AVERAGE ZETA =  .972097, NO. LINES =    248, NO. LINES AFTER REJECT =    248, NO. HW CHANGES =     15


AER TEST CASE - MULTIPLE SCATTERING - RURAL AEROSOL * 900 - 910 CM-1    FASCOD2    86/07/15  16.04.54

THE TIME AT THE START OF RADMRG IS          73.724

INITIAL LAYER     1  FINAL LAYER      4

FILE     10 MERGED WITH FILE     11 ONTO FILE    12
CNTRL AND IANT      3      0

LOCATION  WAVENUMBER  RADIANCE       TRANSMITTANCE                 LOCATION   WAVENUMBER  RADIANCE       TRANSMITTANCE

    1     900.000000  .79474547E-06  .85691011E+00                   622      909.936000  .87619964E-06  .84475863E+00
    2     900.016000  .79482551E-06  .85690086E+00                   623      909.952000  .87421596E-06  .84497517E+00

    3     900.032000  .79493279E-06  .85688830E+00                   624      909.968000  .87549863E-06  .84478947E+00
    4     900.048000  .79505951E-06  .85687303E+00                   625      909.984000  .88452250E-06  .84367647E+00
    5     900.064000  .79521404E-06  .85685402E+00                   626      910.000000  .88599696E-06  .84342465E+00

LOCATION  WAVENUMBER  COMP FLUX UP   COMP REFLECT UP               LOCATION   WAVENUMBER  COMP FLUX UP   COMP REFLECT UP

    1     900.000000  .29946047E-04  .13366350E-01                   622      909.936000  .29309157E-04  .13366577E-01
```

TABLE B-2 (Cont.)

```
  2    900.016000  .29946003E-04  .13366041E-01              623   909.952000  .29389803E-04  .13372409E-01

  3    900.032000  .29945939E-04  .13365607E-01              624   909.968000  .29388291E-04  .13362544E-01
  4    900.048000  .29945853E-04  .13365048E-01              625   909.984000  .29382017E-04  .13325907E-01
  5    900.064000  .29945738E-04  .13364319E-01              626   910.000000  .29379121E-04  .13312143E-01

THE TIME AT THE END OF RADMRG IS       73.822
      .098 SECS WERE REQUIRED FOR THIS MERGE



AER TEST CASE - MULTIPLE SCATTERING - RURAL AEROSOL * 900 - 910 CM-1    FASCOD2   86/07/15  16.04.54

LAYER =        5

**************  CONTINUA: H2O(T),CO2,N2  (01 JULY 82)
                          O2(1600CM-1), O3(DIFFUSE,T), H2O SELF HAS BEEN REDUCED IN THE 800-1200 CM-1 REGION  (01 SEPT 1985)

     LBLF4 *
DV FOR LBLF4 =      .68267     BOUND FOR LBLF4 =    25.0000
N0. LINES BEFORE SHRINK =       638.  NO. LINES AFTER SHRINK =      234.  NO. LINES AFTER REJECT =      219
       TIME            READ    CONVOLUTION         PANEL
     73.959            .026           .052          .000
     MIRAC:
OUTPUT ON FILE     10             DV =     .01066667           BOUNDF3(CM-1) =    2.7307
 LOCATION  WAVENUMBER  OPT. DEPTH                                          LOCATION   WAVENUMBER  OPT. DEPTH

   1025    900.000000  .32986666E-03                                         1958     909.952000  .44633824E-03
   1026    900.010667  .32964266E-03                                         1959     909.962667  .46040205E-03
   1027    900.021333  .32949959E-03                                         1960     909.973333  .48560193E-03
   1028    900.032000  .32961097E-03                                         1961     909.984000  .52292947E-03
   1029    900.042667  .32991037E-03                                         1962     909.994667  .59472190E-03

       TIME            READ    CONVOLUTION         PANEL
     74.062            .013           .056          .012
-------  ----------------  11 HALF WIDTH CHANGES
 AVERAG  WIDTH =  .031216,  AVERAGE ZETA =  .964637, NO. LINES =    192, NO. LINES AFTER REJECT =   192, NO. HW CHANGES =    11


 AER TEST CASE - MULTIPLE SCATTERING - RURAL AEROSOL * 900 - 910 CM-1    FASCOD2    86/07/15  16.04.54

 THE TIME AT THE START OF RADMRG IS        74.076
 INITIAL LAYER     1  FINAL LAYER     5
 FILE    10 MERGED WITH FILE     12 ONTO FILE    11
CNTRL AND IANT     3     0

 LOCATION  WAVENUMBER  RADIANCE       TRANSMITTANCE                   LOCATION   WAVENUMBER  RADIANCE       TRANSMITTANCE
     1     900.000000  .79635011E-06  .85653588E+00                      934     909.952000  .87619631E-06  .84450760E+00

     2     900.010667  .79640699E-06  .85653049E+00                      935     909.962667  .87645349E-06  .84444899E+00
     3     900.021333  .79647188E-06  .85652302E+00                      936     909.973333  .88051167E-06  .84393278E+00
     4     900.032000  .79654644E-06  .85651422E+00                      937     909.984000  .89750159E-06  .84301921E+00

     5     900.042667  .79662934E-06  .85650415E+00                      938     909.994667  .88775920E-06  .84295869E+00
 LOCATION  WAVENUMBER  COMP FLUX UP   COMP REFLECT UP                 LOCATION   WAVENUMBER  COMP FLUX UP   COMP REFLECT UP
```

```
  1     900.000000  .29939846E-04  .13350064E-01          934    909.952000  .29382149E-04  .13350943E-01

  2     900.010667  .29939823E-04  .13349912E-01          935    909.962667  .29381295E-04  .13346148E-01
  3     900.021333  .29939788E-04  .13349662E-01          936    909.973333  .29378045E-04  .13327617E-01
  4     900.032000  .29939742E-04  .13349355E-01          937    909.984000  .2937[illegible]8E-04  .13294134E-01

  5     900.042667  .29939683E-04  .13348985E-01          938    909.994667  .29370781E-04  .13290828E-01

 THE TIME AT THE END OF RADMRG IS        74.222
      .146 SECS WERE REQUIRED FOR THIS MERGE


 AER TEST CASE - MULTIPLE SCATTERING - RURAL AEROSOL * 900 - 910 CM-1    FASCOD2   86/07/15  16.04.54

 LAYER =         6

 ***************  CONTINUA: H2O(T),CO2,N2  (01 JULY 82)
                   O2(1600CM-1), O3(DIFFUSE,T), H2O SELF HAS BEEN REDUCED IN THE 800-1200 CM-1 REGION  (01 SEPT 1985)

      LBLF4 *
 DV FOR LBLF4 =      .68267      BOUND FOR LBLF4 =    25.0000
 NO. LINES BEFORE SHRINK =      638.  NO. LINES AFTER SHRINK =      234.  NO. LINES AFTER REJECT =      219

        TIME               READ    CONVOLUTION            PANEL
      74.364               .026         .052               .000

      HIRAC1
 OUTPUT ON FILE    10            DV =     .01066667          BOUNDF3(CM-1) =   2.7307
                                                            LOCATION   WAVENUMBER   OPT. DEPTH
 LOCATION  WAVENUMBER   OPT. DEPTH
                                                             1958     909.952000  .10895818E-03
   1025     900.000000  .70308145E-04                        1959     909.962667  .11617515E-03
   1026     900.010667  .69991934E-04
                                                             1960     909.973333  .12820501E-03
   1027     900.021333  .69803454E-04                        1961     909.984000  .14943587E-03
   1028     900.032000  .69794544E-04                        1962     909.994667  .18566758E-03
   1029     900.042667  .69924999E-04

        TIME               READ    CONVOLUTION            PANEL
      74.457               .014         .048               .011
 -------------------------  15 HALF WIDTH CHANGES
 AVERAGE WIDTH =  .026035.  AVERAGE ZETA =  .958691. NO. LINES =    192. NO. LINES AFTER REJECT =   192. NO. HW CHANGES =    15


 AER TEST CASE - MULTIPLE SCATTERING - RURAL AEROSOL * 900 - 910 CM-1    FASCOD2   86/07/15  16.04.54

 THE TIME AT THE START OF RADMRG IS        74.471

 INITIAL LAYER     1  FINAL LAYER     6

 FILE    10 MERGED WITH FILE     11 ONTO FILE   12
 CNTRL AND IANT     3     2
                                                         LOCATION  WAVENUMBER   RADIANCE       TRANSMITTANCE
 LOCATION  WAVENUMBER   RADIANCE       TRANSMITTANCE
                                                           934     909.952000  .87663660E-06  .84437320E+00
     1     900.000000  .79671398E-06  .85643263E+00        935     909.962667  .87692450E-06  .84430852E+00
     2     900.010667  .79675983E-06  .85642759E+00
                                                           936     909.973333  .88101697E-06  .84378223E+00
     3     900.021333  .79682414E-06  .85642029E+00        937     909.984000  .88806729E-06  .84285092E+00
     4     900.032000  .79689868E-06  .85641149E+00        938     909.994667  .88842885E-06  .84275988E+00
     5     900.042667  .79698197E-06  .85640131E+00

                                                         LOCATION  WAVENUMBER   COMP FLUX UP   COMP REFLECT UP
 LOCATION  WAVENUMBER   COMP FLUX UP   COMP REFLECT UP
                                                           934     909.952000  .29379560E-04  .13345531E-01
     1     900.000000  .29937858E-04  .13346366E-01
```

```
  2    900.010667  .29937841E-04  .13346200E-01          935    909.962667  .29378589E-04  .13340404E-01

  3    900.021333  .29937809E-04  .13345968E-01          936    909.973333  .29378144E-04  .13321329E-01
  4    900.032000  .29937763E-04  .13345661E-01          937    909.984000  .29368536E-04  .13286889E-01
  5    900.042667  .29937702E-04  .13345285E-01          938    909.994667  .29366951E-04  .13281919E-01

THE TIME AT THE END OF RADMRG IS        74.683
     .132 SECS WERE REQUIRED FOR THIS MERGE



AER TEST CASE - MULTIPLE SCATTERING - RURAL AEROSOL * 900 - 910 CM-1    FASCOD2   86/07/15  16.04.54

LAYER =        7

**************  CONTINUA: H2O(T),CO2,N2  (01 JULY 82)

                      O2(1600CM-1), O3(DIFFUSE,T), H2O SELF HAS BEEN REDUCED IN THE 800-1200 CM-1 REGION  (01 SEPT 1985)

******** IPTS4 =     27 DVR4 =    .91022  BOUND4 = 25.00000    *****

     LBLF4 *
DV FOR LBLF4 =      .91022      BOUND FOR LBLF4 =    25.0000

NO. LINES BEFORE SHRINK =      645.  NO. LINES AFTER SHRINK =      199.  NO. LINES AFTER REJECT =      187

       TIME            READ    CONVOLUTION          PANEL
      74.752           .026          .041            .001

     HIRAC1
OUTPUT ON FILE    10            DV =    .00711111         BOUNDF3(CM-1) =   1.8204

 LOCATION  WAVENUMBER  OPT. DEPTH                                LOCATION   WAVENUMBER  OPT. DEPTH

   1025    900.000000  .11917608E-04                               2427     909.969778  .38045139E-04
   1026    900.007111  .11684389E-04                               2428     909.976889  .34792875E-04
   1027    900.014222  .11524282E-04                               2429     909.984000  .41177882E-04
   1028    900.021333  .11424487E-04                               2430     909.991111  .48594052E-04

   1029    900.028444  .11387777E-04                               2431     909.998222  .60433531E-04

       TIME            READ    CONVOLUTION          PANEL
      74.841           .012          .046            .013

-------------------------   9 HALF WIDTH CHANGES

 AVERAGE WIDTH =  .020994,  AVERAGE ZETA =  .949873, NO. LINES =    150, NO. LINES AFTER REJECT =   150, NO. HW CHANGES =     9


 AER TEST CASE - MULTIPLE SCATTERING - RURAL AEROSOL * 900 - 910 CM-1    FASCOD2   86/07/15  16.04.54

 THE TIME AT THE START OF RADMRG IS       74.856

 INITIAL LAYER    1  FINAL LAYER    7

 FILE    10 MERGED WITH FILE    12 ONTO FILE   11
CNTRL AND IANT    3    0

 LOCATION  WAVENUMBER  RADIANCE       TRANSMITTANCE               LOCATION   WAVENUMBER  RADIANCE      TRANSMITTANCE

      1    900.000000  .79680032E-06  .85639735E+00                1403     909.969778  .87941256E-06  .84395546E+00
      2    900.007111  .79683299E-06  .85639518E+00                1404     909.976889  .88365555E-06  .84340134E+00
      3    900.014222  .79687113E-06  .85639103E+00                1405     909.984000  .88480306E-06  .84274608E+00

      4    900.021333  .79691541E-06  .85638603E+00                1406     909.991111  .88841965E-06  .84273983E+00
      5    900.028444  .79696397E-06  .85638036E+00                1407     909.998222  .88844614E-06  .84272985E+00
```

LOCATION	WAVENUMBER	COMP FLUX UP	COMP REFLECT UP	LOCATION	WAVENUMBER	COMP FLUX UP	COMP REFLECT UP
1	900.000000	.29936992E-04	.13344216E-01	1403	909.969778	.29375357E-04	.13326179E-01
2	900.007111	.29936987E-04	.13344136E-01	1404	909.976889	.29371536E-04	.13305948E-01
3	900.014[illegible]	.29936974[illegible]-04	.13344[illegible]08E-01	1405	909.984[illegible]	.29366255E-04	.13280675E-01
4	900.0213[illegible]	.29936953E-04	.13343844E-01	1406	909.991[illegible]	.29366098E-04	.13280281E-01
5	900.028444	.29936925E-04	.13343649E-01	140[illegible]	909.998222	.29365847E-04	.13279652E-01

THE TIME AT THE END OF RADMRG IS 75.015
.159 SECS WERE REQUIRED FOR THIS MERGE

AER TEST CASE - MULTIPLE SCATTERING - RURAL AEROSOL * 900 - 910 CM-1 FASCOD2 86/07/15 16.04.54

LAYER = 8

************** CONTINUA: H2O(T),CO2,N2 (01 JULY 82)

O2(1600CM-1), O3(DIFFUSE,T), H2O SELF HAS BEEN REDUCED IN THE 800-1200 CM-1 REGION (01 SEPT 1985)

******** IPTS4 = 41 DVR4 = .06681 BOUND4 = 25.00000 *****

LBLF4 *
DV FOR LBLF4 = .06681 BOUND FOR LBLF4 = 25.0000

NO. LINES BEFORE SHRINK = 637. NO. LINES AFTER SHRINK = 253. NO. LINES AFTER REJECT = 238

TIME	READ	CONVOLUTION	PANEL
75.186	.025	.050	.001

MIRAC:
OUTPUT ON FILE 10 DV = .00[illegible] BOUNDF3(CM-1) = 1.2136

LOCATION	WAVENUMBER	OPT. DEPTH	LOCATION	WAVENUMBER	OPT. DEPTH
1025	900.000000	.774[illegible]E-05	2428	906.651259	.18928336E-03
1026	900.004741	.73[illegible]69[illegible]E-05	2429	906.656000	.14229506E-03
1027	900.009481	.7[illegible]23[illegible]92E-05	2430	906.660741	.10942459E-03
1028	900.014222	.6929[illegible]5[illegible]-05	2431	906.665481	.84299405E-04
1029	900.018963	.687174[illegible]-05	2432	906.670222	.66684840E-04
33	906.674963	.54[illegible]3E-04	730	909.979259	.25763877E-04
34	906.[illegible]	.45565[illegible]4E-04	731	909.984000	.30753292E-04
35	906.684444	.389[illegible]3[illegible]E-04	732	909.988741	.37781874E-04
36	906.689185	.34[illegible]E-04	733	909.993481	.47687442E-04
37	906.693926	.3[illegible]-04	734	909.998222	.61148931E-04

TIME	READ	CONVOLUTION	PANEL
75.282	.0[illegible]	.048	.023

--------------------------) HALF WIDTH CHANGES

AVERAGE WIDTH = .[illegible]. AVERAGE ZETA = .928224. NO. LINES = 133. NO. LINES AFTER REJECT = 133. NO. HW CHANGES = 9

AER TEST CASE - MULTIPLE SCATTERING - RURAL AEROSOL * 900 - 910 CM-1 FASCOD2 86/07/15 16.04.54

THE TIME AT THE START OF RADMRG IS 75.296

INITIAL LAYER 1 FINAL LAYER 8

FILE 10 MERGED WITH FILE 11 ONTO FILE 12
CNTRL AND IANT 0

LOCATION	WAVENUMBER	RADIANCE	TRANSMITTANCE	LOCATION	WAVENUMBER	RADIANCE	TRANSMITTANCE
	900.000000	.[illegible]9786624E-06	.85628837E+00	1404	906.651259	.95805770E-06	.83510853E+00

TABLE B-2 (Cont.)

2	900.004741	.79708129E-06	.85627907E+00
3	900.009481	.79710337E-06	.85627690E+00
4	900.014222	.79712950E-06	.85627415E+00
5	900.018963	.79715827E-06	.85627099E+00

LOCATION	WAVENUMBER	COMP FLUX UP	COMP REFLECT UP
1	900.000000	.29933956E-04	.13338483E-01
2	900.004741	.29933962E-04	.13338454E-01
3	900.009481	.29933962E-04	.13338395E-01
4	900.014222	.29933956E-04	.13338312E-01
5	900.018963	.29933945E-04	.13338211E-01
1	906.674963	.99340547E-06	.83146138E+00
2	906.679704	.10060193E-05	.83007647E+00
3	906.684444	.10223497E-05	.82825963E+00
4	906.689185	.10439311E-05	.82583531E+00
5	906.693926	.10719060E-05	.82267098E+00
1	906.674963	.29466535E-04	.12794468E-01
2	906.679704	.29461738E-04	.12754341E-01
3	906.684444	.29455050E-04	.12701469E-01
4	906.689185	.29445567E-04	.12629871E-01
5	906.693926	.29432692E-04	.12535931E-01

THE TIME AT THE END OF RADMRG IS 75.610
.314 SECS WERE REQUIRED FOR THIS MERGE

1405	906.656000	.96297652E-06	.83463638E+00
1406	906.660741	.96870217E-06	.83406839E+00
1407	906.665481	.97538759E-06	.83338414E+00
1408	906.670222	.98343520E-06	.83253651E+00

LOCATION	WAVENUMBER	COMP FLUX UP	COMP REFLECT UP
1404	906.651259	.29473014E-04	.12887323E-01
1405	906.656000	.29473451E-04	.12877605E-01
1406	906.660741	.29473048E-04	.12864501E-01
1407	906.665481	.29471950E-04	.12847642E-01
1408	906.670222	.29469911E-04	.12825222E-01
698	909.979259	.88573981E-06	.84301740E+00
699	909.984000	.88871123E-06	.84260223E+00
700	909.988741	.88875380E-06	.84258507E+00
701	909.993481	.88877141E-06	.84257672E+00
702	909.998222	.88879578E-06	.84256538E+00
698	909.979259	.29365997E-04	.13289592E-01
699	909.984000	.29362531E-04	.13273440E-01
700	909.988741	.29362094E-04	.13272409E-01
701	909.993481	.29361877E-04	.13271953E-01
702	909.998222	.29361582E-04	.13271335E-01

TABLE B-2 (Cont.)

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AER TEST CASE - MULTIPLE SCATTERING - RURAL AEROSOL * 900 - 910 CM-1    FASCOD2   86/07/15  16.04.54

LAYER =         9

**************  CONTINUA: H2O(T),CO2,N2  (01 JULY 82)
                          O2(1600CM-1), O3(DIFFUSE,T), H2O SELF HAS BEEN REDUCED IN THE 800-1200 CM-1 REGION  (01 SEPT 1985)

********  IPTS4 =    32 DVR4 =   .30341  BOUND4 =  9.70904   *****

    LBLF4 *
DV FOR LBLF4 =      .30341     BOUND FOR LBLF4 =    9.7090

N0. LINES BEFORE SHRINK =        471.  NO. LINES AFTER SHRINK =      267.  NO. LINES AFTER REJECT =      158

      TIME              READ    CONVOLUTION           PANEL
     75.788             .026         .054              .001

    HIRAC1
OUTPUT ON FILE    10           DV =     .00237037          BOUNDF3(CM-1) =    .6068

LOCATION  WAVENUMBER  OPT. DEPTH                                         LOCATION   WAVENUMBER  OPT. DEPTH

  1025    900.000000  .21340034E-05                                         2428    903.325630  .13811837E-05
  1026    900.002370  .19528896E-05                                         2429    903.328000  .13799493E-05
  1027    900.004741  .18363804E-05                                         2430    903.330370  .13766500E-05
  1028    900.007111  .17500348E-05                                         2431    903.332741  .13743478E-05
  1029    900.009481  .16923160E-05                                         2432    903.335111  .1373866?E-05

    33    903.337481  .13760292E-05                                         2428    909.014519  .66677133E-05
    34    903.339852  .13766495E-05                                         2429    909.016889  .63094302E-05
    35    903.342222  .13763902E-05                                         2430    909.019259  .59600258E-05
    36    903.344593  .13770112E-05                                         2431    909.021630  .56485783E-05
    37    903.346963  .13778726E-05                                         2432    909.024000  .53726422E-05

    33    909.026370  .51297720E-05                                          440    909.991111  .12253720E-04
    34    909.028741  .49120663E-05                                          441    909.993481  .14547873E-04
    35    909.031111  .47164351E-05                                          442    909.995852  .17418142E-04
    36    909.033481  .45384742E-05                                          443    909.998222  .21404088E-04
    37    909.035852  .43737789E-05                                          444    910.000593  .26909083E-04

      TIME              READ    CONVOLUTION           PANEL
     75.899             .012         .036              .041

------------------------     7 HALF WIDTH CHANGES

AVERAGE WIDTH =  .007145,  AVERAGE ZETA =  .870008, NO. LINES =    110, NO. LINES AFTER REJECT =   110, NO. HW CHANGES =     7


AER TEST CASE - MULTIPLE SCATTERING - RURAL AEROSOL * 900 - 910 CM-1    FASCOD2   86/07/15  16.04.54

THE TIME AT THE START OF RADMRG IS       75.913

INITIAL LAYER    1  FINAL LAYER    9
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FILE     10 MERGED WITH FILE     12 ONTO FILE    11
CNTRL AND IANT    3    0
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LOCATION	WAVENUMBER	RADIANCE	TRANSMITTANCE
1	900.000000	.79727294E-06	.85618640E+00
2	900.002370	.79727874E-06	.85618604E+00
3	900.004741	.79728742E-06	.85618535E+00
4	900.007111	.79729761E-06	.85618444E+00
5	900.009481	.79730924E-06	.85618332E+00

LOCATION	WAVENUMBER	COMP FLUX UP	COMP REFLECT UP
1	900.000000	.29931377E-04	.13333891E-01
2	900.002370	.29931384E-04	.13333889E-01
3	900.004741	.29931390E-04	.13333876E-01
4	900.007111	.29931393E-04	.13333854E-01
5	900.009481	.29931394E-04	.13333824E-01
1	903.337481	.78762085E-06	.85655657E+00
2	903.339852	.78759618E-06	.85655605E+00
3	903.342222	.78757567E-06	.85655460E+00
4	903.344593	.78755885E-06	.85655235E+00
5	903.346963	.78754558E-06	.85654934E+00
1	903.337481	.29776153E-04	.13442347E-01
2	903.339852	.29776149E-04	.13443451E-01
3	903.342222	.29776139E-04	.13444655E-01
4	903.344593	.29776122E-04	.13445944E-01
5	903.346963	.29776100E-04	.13447313E-01
1	909.026370	.66545445E-05	.19314697E+00
2	903.028741	.65040747E-05	.2[illegible]875124E+00
3	909.031111	.63554784E-05	.2[illegible]29957E+00
4	909.033431	.62080273E-05	.2[illegible]79460E+00
5	909.035852	.60632190E-05	.25517024E+00
1	909.026370	.26659025E-04	.11006554E-02
2	909.028741	.26932991E-04	.12270630E-02
3	909.031111	.27001680E-04	.13511054E-02
4	909.033481	.27038040E-04	.14786104E-02
5	909.035852	.27017522E-04	.16080311E-02

THE TIME AT THE END OF RADMRG IS   76.493
   .580 SECS WERE REQUIRED FOR THIS MERGE

LOCATION	WAVENUMBER	RADIANCE	TRANSMITTANCE
1404	903.325630	.78781928E-06	.85654195E+00
1405	903.328000	.78776766E-06	.85654778E+00
1406	903.330370	.78772295E-06	.85655189E+00
1407	903.332741	.78768388E-06	.85655465E+00
1408	903.335111	.78764977E-06	.85655625E+00

LOCATION	WAVENUMBER	COMP FLUX UP	COMP REFLECT UP
1404	903.325630	.29776057E-04	.13438868E-01
1405	903.328000	.29776101E-04	.13439213E-01
1406	903.330370	.29776128E-04	.13439780E-01
1407	903.332741	.29776145E-04	.13440507E-01
1408	903.335111	.29776155E-04	.13441368E-01
2396	909.014519	.74190130E-05	.11659032E+00
2397	909.016889	.72701287E-05	.13114517E+00
2398	909.019259	.71168485E-05	.14630885E+00
2399	909.021630	.69617926E-05	.16182887E+00
2400	909.024000	.68075892E-05	.17745863E+00
2396	909.014519	.20719149E-04	.41151476E-03
2397	909.016889	.22146717E-04	.53716809E-03
2398	909.019259	.23645375E-04	.67856671E-03
2399	909.021630	.25000981E-04	.82480868E-03
2400	909.024000	.25986981E-04	.96505666E-03
408	909.991111	.88901445E-06	.84246264E+00
409	909.993481	.88901858E-06	.84246071E+00
410	909.995852	.88902375E-06	.84245829E+00
411	909.998222	.88903093E-06	.84245493E+00
412	910.000593	.88904099E-06	.84245023E+00
408	909.991111	.29358745E-04	.13266210E-01
409	909.993481	.29358691E-04	.13266104E-01
410	909.995852	.29358624E-04	.13265972E-01
411	909.998222	.29358531E-04	.13265789E-01
412	910.000593	.29358401E-04	.13265532E-01

TABLE B-2 (Cont.)

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AER TEST CASE - MULTIPLE SCATTERING - RURAL AEROSOL * 900 - 910 CM-1     FASCOD2    86/07/15  16.04.54

LAYER =       10

************** CONTINUA: H2O(T),CO2,N2  (01 JULY 82)

                   O2(1600CM-1), O3(DIFFUSE,T), H2O SELF HAS BEEN REDUCED IN THE 800-1200 CM-1 REGION  (01 SEPT 1985)

******** IPTS4 =    32 DVR4 =   .20227  BOUND4 =  6.47269   *****

     LBLF4 *
DV FOR LBLF4 =      .20227     BOUND FOR LBLF4 =    6.4727

N0. LINES BEFORE SHRINK =      441,  NO. LINES AFTER SHRINK =     280,  NO. LINES AFTER REJECT =      143

        TIME           READ    CONVOLUTION         PANEL
      76.688           .024           .056          .001

    HIRAC1
OUTPUT ON FILE    10            DV =    .00158025         BOUNDF3(CM-1) =    .4045

LOCATION  WAVENUMBER  OPT. DEPTH                                    LOCATION  WAVENUMBER  OPT. DEPTH

   1025   900.000000  .12554139E-06                                   2428   902.217006  .28091019E-05
   1026   900.001580  .11621700E-06                                   2429   902.218667  .34286468E-05
   1027   900.003160  .10949777E-06                                   2430   902.220247  .42199614E-05
   1028   900.004741  .10457647E-06                                   2431   902.221827  .53086014E-05

   1029   900.006321  .10094832E-06                                   2432   902.223407  .69615145E-05

     33   902.224988  .93863494E-05                                   2428   906.009679  .35344142E-06
     34   902.226568  .12630317E-04                                   2429   906.011259  .34045163E-06
     35   902.228148  .17208632E-04                                   2430   906.012840  .32836798E-06
     36   902.229728  .22065470E-04                                   2431   906.014420  .31741517E-06

     37   902.231309  .24529301E-04                                   2432   906.016000  .30755696E-06

     33   906.017580  .29875703E-06                                   2428   909.802272  .99224859E-07
     34   906.019160  .29039775E-06                                   2429   909.803852  .99954126E-07
     35   906.020741  .28287408E-06                                   2430   909.805432  .99860385E-07
     36   906.022321  .27619096E-06                                   2431   909.807012  .99906247E-07

     37   906.023901  .27035331E-06                                   2432   909.808593  .10017110E-06

     33   909.810173  .10073431E-06                                    149   909.993481  .86682498E-06
     34   909.811753  .10145024E-06                                    150   909.995062  .10036428E-05
     35   909.813333  .10228269E-06                                    151   909.996642  .11534512E-05
     36   909.814914  .10323056E-06                                    152   909.998222  .13199642E-05

     37   909.816494  .10451685E-06                                    153   909.999802  .15449143E-05

        TIME           READ    CONVOLUTION         PANEL
      76.816           .011           .031          .058

------------------------  4 HALF WIDTH CHANGES

AVERAGE WIDTH =  .004655,  AVERAGE ZETA =  .017436, NO. LINES =    103, NO. LINES AFTER REJECT =   103, NO. HW CHANGES =     4
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TABLE B-2 (Cont.)

AER TEST CASE - MULTIPLE SCATTERING - RURAL AEROSOL * 900 - 910 CM-1   FASCOD2   86/07/15 16.04.54

THE TIME AT THE START OF RADMRG IS   76.829

INITIAL LAYER   1   FINAL LAYER   10

FILE   10 MERGED WITH FILE   11 ONTO FILE   12
CNTRL AND IANT   3   2

LOCATION	WAVENUMBER	RADIANCE	TRANSMITTANCE	LOCATION	WAVENUMBER	RADIANCE	TRANSMITTANCE
1	900.000000	.79730901E-06	.85617046E+00	1404	902.217086	.83165291E-06	.85102450E+00
2	900.001580	.79731139E-06	.85617027E+00	1405	902.218667	.83220234E-06	.85093402E+00
3	900.003160	.79731642E-06	.85616992E+00	1406	902.220247	.83272127E-06	.85084592E+00
4	900.004741	.79732245E-06	.85616943E+00	1407	902.221827	.83321259E-06	.85076012E+00
5	900.006321	.79732907E-06	.85616885E+00	1408	902.223407	.83367587E-06	.85067694E+00
LOCATION	WAVENUMBER	COMP FLUX UP	COMP REFLECT UP	LOCATION	WAVENUMBER	COMP FLUX UP	COMP REFLECT UP
1	900.000000	.29930870E-04	.13332985E-01	1404	902.217086	.29795317E-04	.13204466E-01
2	900.001580	.29930874E-04	.13332904E-01	1405	902.218667	.29794486E-04	.13200284E-01
3	900.003160	.29930879E-04	.13332900E-01	1406	902.220247	.29793329E-04	.13196235E-01
4	900.004741	.29930883E-04	.13332891E-01	1407	902.221827	.29792148E-04	.13192288E-01
5	900.006321	.29930885E-04	.13332877E-01	1408	902.223407	.29790947E-04	.13188449E-01
1	902.224988	.83411056E-06	.85059627E+00	2396	906.009679	.90857094E-06	.84147561E+00
2	902.226568	.83451276E-06	.85051972E+00	2397	906.011259	.90966279E-06	.84136043E+00
3	902.228148	.83487603E-06	.85044998E+00	2398	906.012840	.91082714E-06	.84123647E+00
4	902.229728	.83518655E-06	.85039297E+00	2399	906.014420	.91205624E-06	.84110468E+00
5	902.231309	.83542908E-06	.85035581E+00	2400	906.016000	.91337121E-06	.84096613E+00
1	902.224988	.29789716E-04	.13184706E-01	2396	906.009679	.29543549E-04	.13086416E-01
2	902.226568	.29788497E-04	.13181150E-01	2397	906.011259	.29543311E-04	.13083476E-01
3	902.228148	.29787358E-04	.13177921E-01	2398	906.012840	.29543136E-04	.13080235E-01
4	902.229728	.29786461E-04	.13175346E-01	2399	906.014420	.29542975E-04	.13076729E-01
5	902.231309	.29786015E-04	.13173825E-01	2400	906.016000	.29542775E-04	.13072997E-01
1	906.017580	.91466580E-06	.84082274E+00	2396	909.802272	.93202373E-06	.83762962E+00
2	906.019160	.91604758E-06	.84067250E+00	2397	909.803852	.93392158E-06	.83739263E+00
3	906.020741	.91749586E-06	.84051434E+00	2398	909.805432	.93578674E-06	.83715874E+00
4	906.022321	.91901685E-06	.84034759E+00	2399	909.807012	.93760808E-06	.83692923E+00
5	906.023901	.92061503E-06	.84017171E+00	2400	909.808593	.93937286E-06	.83670569E+00
1	906.017580	.29542459E-04	.13069107E-01	2396	909.802272	.29340620E-04	.13114006E-01
2	906.019160	.29542075E-04	.13064991E-01	2397	909.803852	.29339208E-04	.13105034E-01
3	906.020741	.29541640E-04	.13060614E-01	2398	909.805432	.29337783E-04	.13096117E-01
4	906.022321	.29541163E-04	.13055958E-01	2399	909.807012	.29336361E-04	.13087309E-01
5	906.023901	.29540635E-04	.13050987E-01	2400	909.808593	.29334951E-04	.13078669E-01
1	909.810173	.94106575E-06	.83649006E+00	117	909.993481	.98905602E-06	.84244313E+00
2	909.811753	.94260033E-06	.83628309E+00	118	909.995062	.98905954E-06	.84244148E+00

TABLE B-2 (Cont.)

3	909.813333	.94420954E-06	.83608537E+00	119	909.996642	.88906383E-06	.84243948E+00
4	909.814914	.94564897E-06	.83559666E+00	120	909.998222	.88907422E-06	.84243462E+00
5	909.816494	.94698009E-06	.83572059E+00	121	909.999802	.88907462E-06	.84243443E+00
1	909.810173	.29333566E-04	.13070273E-01	117	909.993481	.29358130E-04	.13265004E-01
2	909.811753	.29332209E-04	.13062149E-01	118	909.995062	.29358084E-04	.13264913E-01
3	909.813333	.29330876E-04	.13054305E-01	119	909.996642	.29358028E-04	.13264802E-01
4	909.814914	.29329551E-04	.13046597E-01	120	909.998222	.29357893E-04	.13264536E-01
5	909.816494	.29328281E-04	.13039525E-01	121	909.999802	.29357887E-04	.13264524E-01

THE TIME AT THE END OF RADMRG IS 77.452
.623 SECS WERE REQUIRED FOR THIS MERGE

TABLE B-2 (Cont.)

THE TIME AT THE START OF FLXDWN IS 77.500

FLXDWN - LAYER 10 WITH 4 PANELS

LOCATION	WAVENUMBER	COMP FLUX DN	COMP REFLECT DN
1	900.000000	.59189586E-09	.00000000E+00
2	900.001580	.59159678E-09	.00000000E+00
3	900.003160	.59138170E-09	.00000000E+00
4	900.004741	.59122422E-09	.00000000E+00
5	900.006321	.59118913E-09	.00000000E+00

LOCATION	WAVENUMBER	TOTAL FLUX UP	TOTAL FLUX DN
1	900.000000	.29930870E-04	.00000000E+00
2	900.001580	.29930874E-04	.00000000E+00
3	900.003160	.29930879E-04	.00000000E+00
4	900.004741	.29930893E-04	.00000000E+00
5	900.006321	.29930885E-04	.00000000E+00
1	902.224988	.89658320E-09	.00000000E+00
2	902.226568	.99982727E-09	.00000000E+00
3	902.228148	.11455389E-08	.00000000E+00
4	902.229728	.13081158E-08	.00000000E+00
5	902.231309	.13785301E-08	.00000000E+00
1	902.224988	.29789716E-04	.00000000E+00
2	902.226568	.29783497E-04	.00000000E+00
3	902.228148	.29787358E-04	.00000000E+00
4	902.229728	.29786461E-04	.00000000E+00
5	902.231309	.29786015E-04	.00000000E+00
1	906.017580	.62190959E-09	.00000000E+00
2	906.019160	.62164598E-09	.00000000E+00
3	906.020741	.62140872E-09	.00000000E+00
4	906.022321	.62119796E-09	.00000000E+00
5	906.023901	.62101389E-09	.00000000E+00
1	906.017580	.29542459E-04	.00000000E+00
2	906.019160	.29542075E-04	.00000000E+00
3	906.020741	.29541640E-04	.00000000E+00
4	906.022321	.29541163E-04	.00000000E+00
5	906.023901	.29540635E-04	.00000000E+00
1	909.810173	.62415261E-09	.00000000E+00
2	909.811753	.62417498E-09	.00000000E+00
3	909.813333	.62420099E-09	.00000000E+00
4	909.814914	.62423060E-09	.00000000E+00
5	909.816494	.62427079E-09	.00000000E+00
1	909.810173	.29333566E-04	.00000000E+00
2	909.811753	.29332209E-04	.00000000E+00
3	909.813333	.29330876E-04	.00000000E+00

LOCATION	WAVENUMBER	COMP FLUX DN	COMP REFLECT DN
1404	902.217086	.68687036E-09	.00000000E+00
1405	902.218667	.70659578E-09	.00000000E+00
1406	902.220247	.73178991E-09	.00000000E+00
1407	902.221827	.76899757E-09	.00000000E+00
1408	902.223407	.81907665E-09	.00000000E+00

LOCATION	WAVENUMBER	TOTAL FLUX UP	TOTAL FLUX DN
1404	902.217086	.29795617E-04	.00000000E+00
1405	902.218667	.29794486E-04	.00000000E+00
1406	902.220247	.29793329E-04	.00000000E+00
1407	902.221827	.29792148E-04	.00000000E+00
1408	902.223407	.29790947E-04	.00000000E+00
2396	906.009679	.62346220E-09	.00000000E+00
2397	906.011259	.62305249E-09	.00000000E+00
2398	906.012840	.62267.36E-09	.00000000E+00
2399	906.014420	.62232591E-09	.00000000E+00
2400	906.016000	.62201497E-09	.00000000E+00
2396	906.009679	.29543549E-04	.00000000E+00
2397	906.011259	.29543311E-04	.00000000E+00
2398	906.012840	.29543136E-04	.00000000E+00
2399	906.014420	.29542975E-04	.00000000E+00
2400	906.016000	.29542775E-04	.00000000E+00
2396	909.802272	.62364886E-09	.00000000E+00
2397	909.803852	.62364978E-09	.00000000E+00
2398	909.805432	.62364685E-09	.00000000E+00
2399	909.807012	.62364828E-09	.00000000E+00
2400	909.808593	.62365656E-09	.00000000E+00
2396	909.802272	.29340628E-04	.00000000E+00
2397	909.803852	.29339208E-04	.00000000E+00
2398	909.805432	.29337783E-04	.00000000E+00
2399	909.807012	.29336361E-04	.00000000E+00
2400	909.808593	.29334951E-04	.00000000E+00
117	909.993481	.64800805E-09	.00000000E+00
118	909.995062	.65236273E-09	.00000000E+00
119	909.996642	.65704329E-09	.00000000E+00
120	909.998222	.66224576E-09	.00000000E+00
121	909.999802	.66927401E-09	.00000000E+00
117	909.993481	.29358130E-04	.00000000E+00
118	909.995062	.29358084E-04	.00000000E+00
119	909.996642	.29358028E-04	.00000000E+00

TABLE B-2 (Cont.)

4	909.814914	.23329551E-04	.00000000E+00
5	909.816494	.29328281E-04	.00000000E+00

FLXDWN - LAYER 9 WITH 3 PANELS

LOCATION	WAVENUMBER	COMP FLUX DN	COMP REFLECT DN
1	900.000000	.36113400E-08	.43371711E-06
2	900.002370	.36058868E-08	.43371725E-06
3	900.004741	.36023894E-08	.43371734E-06
4	900.007111	.35998231E-08	.43371740E-06
5	900.009481	.35981071E-08	.43371745E-06

LOCATION	WAVENUMBER	TOTAL FLUX UP	TOTAL FLUX DN
1	900.000000	.29931425E-04	.36243218E-08
2	900.002370	.29931433E-04	.36188686E-08
3	900.004741	.29931438E-04	.36153712E-08
4	900.007111	.29931441E-04	.36128048E-08
5	900.009481	.29931442E-04	.36110889E-08
1	903.337481	.36789718E-08	.43379118E-06
2	903.339852	.36789727E-08	.43379118E-06
3	903.3'2222	.36789828E-08	.43379118E-06
4	903.344593	.36790009E-08	.43379118E-06
5	903.346963	.36790261E-08	.43379118E-06
1	903.337481	.29776203E-04	.36918884E-08
2	903.339852	.29776199E-04	.36918894E-08
3	903.342222	.29776188E-04	.36918994E-08
4	903.344593	.29776172E-04	.36919175E-08
5	903.346963	.29776149E-04	.36919427E-08
1	909.026370	.38863290E-08	.43425764E-06
2	909.028741	.38799217E-08	.43425780E-06
3	909.031111	.38741783E-08	.43425795E-06
4	909.033481	.38689639E-08	.43425808E-06
5	909.035852	.38641453E-08	.43425821E-06
1	909.026370	.26659029E-04	.38979059E-08
2	909.028741	.26932996E-04	.38916176E-08
3	909.031111	.27001686E-04	.38859040E-08
4	909.033481	.27038046E-04	.38807054E-08
5	909.035852	.27017528E-04	.38758779E-08

120	909.998222	.29357893E-04	.00000000E+00
121	909.999802	.29357887E-04	.00000000E+00

LOCATION	...ER	COMP FLUX DN	COMP REFLECT DN
1404	903.. .30	.36734700E-08	.43344766E-06
1405	903.328000	.36734343E-08	.43344766E-06
1406	903.330370	.36733422E-08	.43344767E-06
1407	903.332741	.36732783E-08	.43344767E-06
1408	903.335111	.36732651E-08	.43344767E-06

LOCATION	WAVENUMBER	TOTAL FLUX UP	TOTAL FLUX DN
1404	903.325630	.29776106E-04	.36863764E-08
1405	903.328000	.29776150E-04	.36863407E-08
1406	903.330370	.29776178E-04	.36862486E-08
1407	903.332741	.29776195E-04	.36861847E-08
1408	903.335111	.29776205E-04	.36861716E-08
2396	909.014519	.39297860E-08	.43404378E-06
2397	909.016889	.39192274E-08	.43404405E-06
2398	909.019259	.39089642E-08	.43404431E-06
2399	909.021630	.38997807E-08	.43404454E-06
2400	909.024000	.38916201E-08	.43404475E-06
2396	909.014519	.20719150E-04	.39387790E-08
2397	909.016889	.22146719E-04	.39288401E-08
2398	909.019259	.23645378E-04	.39192273E-08
2399	909.021630	.25000984E-04	.39106323E-08
2400	909.024000	.25986985E-04	.39028996E-08
408	909.991111	.41053398E-08	.43435789E-06
409	909.993481	.41719621E-08	.43435616E-06
410	909.995852	.42564780E-08	.43435400E-06
411	909.998222	.43723400E-08	.43435190E-06
412	910.000593	.45315879E-08	.43428753E-06
408	909.991111	.29358799E-04	.41100920E-08
409	909.993481	.29358747E-04	.41847143E-[illegible]
410	909.995852	.29358681E-04	.42692301E-[illegible]
411	909.998222	.29358590E-04	.43850920E-08
412	910.000593	.29358461E-04	.45443379E-08

TABLE B-2 (Cont.)

THE TIME AT THE START OF SRCFCN IS 78.460

SRCFCN - LAYER 10 WITH 4 PANELS

LOCATION	WAVENUMBER	MSCAT SRC FCN	MS TRANS
1	900.000000	.40583627E-12	.99998150E+00
2	900.001580	.40583630E-12	.99998151E+00
3	900.003160	.40583635E-12	.99998152E+00
4	900.004741	.40583638E-12	.99998152E+00
5	900.006321	.40583640E-12	.99998153E+00
1	902.224988	.40400495E-12	.99997183E+00
2	902.226568	.40399349E-12	.99996859E+00
3	902.228148	.40398331E-12	.99996401E+00
4	902.229728	.40397568E-12	.99995915E+00
5	902.231309	.40397158E-12	.99995669E+00
1	906.01758[illegible]	.40080088E-12	.99998028E+00
2	906.019160	.40079566E-12	.99998029E+00
3	906.020741	.40078972E-12	.99998029E+00
4	906.022321	.40078322E-12	.99998030E+00
5	906.023901	.40077606E-12	.99998031E+00
1	909.810173	.39834708E-12	.99998002E+00
2	909.811753	.39832874E-12	.99998002E+00
3	909.813333	.39831061E-12	.99998002E+00
4	909.814914	.39829256E-12	.99998002E+00
5	909.816494	.39827541E-12	.99998002E+00

LOCATION	WAVENUMBER	MSCAT SRC FCN	MS TRANS
1404	902.217086	.40384544E-12	.99997843E+00
1405	902.218667	.40383171E-12	.99997781E+00
1406	902.220247	.40381810E-12	.99997702E+00
1407	902.221827	.40380481E-12	.99997585E+00
1408	902.223407	.40379190E-12	.99997427E+00
2396	906.009679	.40064191E-12	.99998023E+00
2397	906.011259	.40063862E-12	.99998025E+00
2398	906.012840	.40063622E-12	.99998026E+00
2399	906.014420	.40063400E-12	.99998027E+00
2400	906.016000	.40063125E-12	.99998028E+00
2396	909.802272	.39832113E-12	.99998004E+00
2397	909.803852	.39830180E-12	.99998004E+00
2398	909.805432	.39828241E-12	.99998004E+00
2399	909.807012	.39826320E-12	.99998004E+00
2400	909.808593	.39824402E-12	.99998004E+00
117	909.993481	.39868338E-12	.99997926E+00
118	909.995062	.39868314E-12	.99997912E+00
119	909.996642	.39868285E-12	.99997897E+00
120	909.998222	.39868205E-12	.99997800E+00
121	909.999802	.39868215E-12	.99997858E+00

THE TIME AT THE END OF SRCFCN IS 79.705
1.245 SECS WERE REQUIRED FOR THIS MERGE

FLXDWN - LAYER 8 WITH 2 PANELS

LOCATION	WAVENUMBER	COMP FLUX DN	COMP REFLECT DN
1	900.000000	.75748798E-08	.98689030E-06
2	900.004741	.75550626E-08	.98689144E-06
3	900.009481	.75426239E-08	.98689224E-06
4	900.014222	.75355454E-08	.98689270E-06
5	900.018963	.75315485E-08	.98689297E-06

LOCATION	WAVENUMBER	COMP FLUX DN	COMP REFLECT DN
1404	906.651259	.15671805E-07	.98752986E-06
1405	906.656000	.13292987E-07	.98767128E-06
1406	906.660741	.11812993E-07	.98776572E-06
1407	906.665481	.10787906E-07	.98783528E-06
1408	906.670222	.10085680E-07	.98788364E-06

LOCATION	WAVENUMBER	TOTAL FLUX UP	TOTAL FLUX DN
1	900.000000	.29934058E-04	.76044215E-08
2	900.004741	.29934063E-04	.75846042E-08
3	900.009481	.29934063E-04	.75721656E-08
4	900.014222	.29934057E-04	.75650871E-08
5	900.018963	.29934046E-04	.75610902E-08
1	906.674963	.96048072E-08	.98836560E-06
2	906.679704	.92803619E-08	.98838865E-06

LOCATION	WAVENUMBER	TOTAL FLUX UP	TOTAL FLUX DN
1404	906.651259	.29473216E-04	.15700911E-07
1405	906.656000	.29473623E-04	.13322097E-07
1406	906.660741	.29473200E-04	.11842112E-07
1407	906.665481	[illegible]	.10817019E-07
1408	906.670222	[illegible]	.10114793E-07
698	909.979259	[illegible]	.98985627E-06
699	909.984000	.88126835E-08	.98984200E-06

TABLE B-2 (Cont.)

3	9Ø6.684444	.9Ø3Ø1884E-Ø9	.9884Ø659E-Ø6	7ØØ	9Ø9.988741	.9Ø826Ø91E-Ø8	.98982367E-Ø6
4	9Ø6.689185	.88465283E-Ø8	.98841971E-Ø6	7Ø1	9Ø9.993481	.948Ø9968E-Ø8	.98979625E-Ø6
5	9Ø6.693926	.871714Ø8E-Ø8	.98842891E-Ø6	7Ø2	9Ø9.998222	.1ØØ65443E-Ø7	.9897579ØE-Ø6
1	9Ø6.674963	.29466658E-Ø4	.96339311E-Ø8	698	9Ø9.979259	.29366112E-Ø4	.86543826E-Ø8
2	9Ø6.6797Ø4	.29461857E-Ø4	.93Ø94817E-Ø8	699	9Ø9.984ØØØ	.29362645E-Ø4	.88417479E-Ø8
3	9Ø6.684444	.294551[illegible]E-Ø4	.9Ø5938Ø2ØE-Ø8	7ØØ	9Ø9.988741	.29362215E-Ø4	.91116725E-Ø8
4	9Ø6.689185	.2[illegible]445680E-Ø4	.8875633ØE-Ø8	7Ø1	9Ø9.993481	.293628Ø3E-Ø4	.951ØØ592E-Ø8
5	9Ø6.693926	.294328Ø2E-Ø4	.8746233ØE-Ø8	7Ø2	9Ø9.998222	.29361716E-Ø4	.1ØØ945Ø4E-Ø7

TABLE B-2 (Cont.)

THE TIME AT THE START OF SRCFCN IS 79.990

SRCFCN - LAYER 9 WITH 3 PANELS

LOCATION	WAVENUMBER	MSCAT SRC FCN	MS TRANS	LOCATION	WAVENUMBER	MSCAT SRC FCN	MS TRANS
1	900.000000	.23617228E-11	.99989097E+00	1404	903.325630	.23481175E-11	.99988833E+00
2	900.002370	.23617228E-11	.99989115E+00	1405	903.328000	.23481209E-11	.99988833E+00
3	900.004741	.23617227E-11	.99989127E+00	1406	903.330370	.23481231E-11	.99988834E+00
4	900.007111	.23617225E-11	.99989136E+00	1407	903.332741	.23481244E-11	.99988834E+00
5	900.009481	.23617223E-11	.99989141E+00	1408	903.335111	.23481253E-11	.99988834E+00
1	903.337481	.23499904E-11	.99988813E+00	2396	909.014519	.16364615E-11	.99987840E+00
2	903.339852	.23499901E-11	.99988813E+00	2397	909.016889	.17491729E-11	.99987876E+00
3	903.342222	.23499893E-11	.99988813E+00	2398	909.019259	.18674989E-11	.99987911E+00
4	903.344593	.23499880E-11	.99988813E+00	2399	909.021630	.19745306E-11	.99987942E+00
5	903.346963	.23499862E-11	.99988812E+00	2400	909.024000	.20523796E-11	.99987970E+00
1	909.026370	.21064724E-11	.99987977E+00	408	909.991111	.23203110E-11	.99987207E+00
2	909.028741	.21281097E-11	.99987999E+00	409	909.993481	.23203143E-11	.99986978E+00
3	909.031111	.21335306E-11	.99988019E+00	410	909.995852	.23203189E-11	.99986691E+00
4	909.033481	.21363982E-11	.99988036E+00	411	909.998222	.23203214E-11	.99986292E+00
5	909.035852	.21347730E-11	.99988053E+00	412	910.000593	.23200015E-11	.99985733E+00

THE TIME AT THE START OF MSEMIS IS 80.832

INITIAL LAYER 1 FINAL LAYER 10

FILE 27 MERGED WITH FILE 26 ONTO FILE 28 WITH XTYPE= -2.5000

LOCATION	WAVENUMBER	MS EMISSION	MS TRANS	LOCATION	WAVENUMBER	MS EMISSION	MS TRANS
1	900.000000	.27675148E-11	.99998150E+00	1404	902.217086	.27540892E-11	.99997843E+00
2	900.001580	.27675149E-11	.99998151E+00	1405	902.218667	.27540135E-11	.99997781E+00
3	900.003160	.27675149E-11	.99998152E+00	1406	902.220247	.27539416E-11	.99997702E+00
4	900.004741	.27675149E-11	.99998152E+00	1407	902.221827	.27538749E-11	.99997585E+00
5	900.006321	.27675149E-11	.99998153E+00	1408	902.223407	.27538136E-11	.99997427E+00
1	902.224988	.27539893E-11	.99997183E+00	2396	906.009679	.27328239E-11	.99998023E+00
2	902.226568	.27539470E-11	.99996859E+00	2397	906.011259	.27328268E-11	.99998025E+00
3	902.228148	.27539105E-11	.99996401E+00	2398	906.012840	.27328094E-11	.99998026E+00
4	902.229728	.27538838E-11	.99995915E+00	2399	906.014420	.27327935E-11	.99998027E+00
5	902.231309	.27538712E-11	.99995669E+00	2400	906.016000	.27327739E-11	.99998028E+00
1	906.017580	.27329176E-11	.99998028E+00	2396	909.802272	.27152407E-11	.99998004E+00
2	906.019160	.27328815E-11	.99998029E+00	2397	909.803852	.27151087E-11	.99998004E+00
3	906.020741	.27328403E-11	.99998029E+00	2398	909.805432	.27149763E-11	.99998004E+00
4	906.022321	.27327952E-11	.99998030E+00	2399	909.807012	.27149460E-11	.99998004E+00
5	906.023901	.27327460E-11	.99998031E+00	2400	909.808593	.27147151E-11	.99998004E+00
1	909.810173	.27147084E-11	.99998002E+00	117	909.993481	.27189458E-11	.99997926E+00
2	909.811753	.27145842E-11	.99998002E+00	118	909.995062	.27189480E-11	.99997912E+00
3	909.813333	.27144605E-11	.99998002E+00	119	909.996642	.27189650E-11	.99997897E+00

4	909.814914	.27143375E-11	.99998002E+00
5	909.816494	.27142214E-11	.99998002E+00

THE TIME AT THE END OF MSEMIS IS 81.016
.184 SECS WERE REQUIRED FOR THIS MERGE

THE TIME AT THE END OF SRCFCN IS 81.017
1.027 SECS WERE REQUIRED FOR THIS MERGE

FLXDWN - LAYER 7 WITH 1 PANELS

LOCATION	WAVENUMBER	COMP FLUX DN	COMP REFLECT DN
1	900.000000	.90991840E-08	.98673132E-06
2	900.007111	.90635268E-08	.98673382E-06
3	900.014222	.90449666E-08	.98673527E-06
4	900.021333	.90358930E-08	.98673602E-06
5	900.028444	.90326732E-08	.98673629E-06

LOCATION	WAVENUMBER	TOTAL FLUX UP	TOTAL FLUX DN
1	900.000000	.29937114E-04	.91287239E-08
2	900.007111	.29937108E-04	.90930668E-08
3	900.014222	.29937095E-04	.90745066E-08
4	900.021333	.29937074E-04	.90654330E-08
5	900.028444	.29937046E-04	.90622131E-08

120	909.998222	.27180488E-11	.99997880E+00
121	909.999802	.27187291E-11	.99997858E+00

LOCATION	WAVENUMBER	COMP FLUX DN	COMP REFLECT DN
1403	909.969778	.10558655E-07	.98964098E-06
1404	909.976889	.10906342E-07	.98960959E-06
1405	909.984000	.11409806E-07	.98956500E-06
1406	909.991111	.12133693E-07	.98950401E-06
1407	909 998222	.13375050E-07	.98940398E-06

LOCATION	WAVENUMBER	TOTAL FLUX UP	TOTAL FLUX DN
1403	909.969778	.29375498E-04	.10587727E-07
1404	909.976889	.29371681E-04	.10935409E-07
1405	909.984000	.29366407E-04	.11438866E-07
1406	909.991111	.29366259E-04	.12162751E-07
1407	909.998222	.29366025E-04	.13404105E-07

TABLE B-2 (Cont.)

THE TIME AT THE START OF SRCFCN IS 81.161

SRCFCN - LAYER 8 WITH 2 PANELS

LOCATION	WAVENUMBER	MSCAT SRC FCN	MS TRANS	LOCATION	WAVENUMBER	MSCAT SRC FCN	MS TRANS
1	900.000000	.29913370E-11	.99986363E+00	1404	906.651259	.29521113E-11	.99967443E+00
2	900.004741	.29913353E-11	.99986400E+00	1405	906.656000	.29518618E-11	.99972141E+00
3	900.009481	.29913337E-11	.99986428E+00	1406	906.660741	.29516309E-11	.99975427E+00
4	900.014222	.29913321E-11	.99986445E+00	1407	906.665481	.29513883E-11	.99977939E+00
5	900.018963	.29913305E-11	.99986454E+00	1408	906.670222	.29510886E-11	.99979700E+00
1	906.674963	.29530790E-11	.99980933E+00	698	909.979259	.29460554E-11	.99983526E+00
2	906.679704	.29525616E-11	.99981787E+00	699	909.984000	.29457352E-11	.99983027E+00
3	906.684444	.29518497E-11	.99982455E+00	700	909.988741	.29457249E-11	.99982325E+00
4	906.689185	.29508679E-11	.99982943E+00	701	909.993481	.29457667E-11	.99981334E+00
5	906.693926	.29495632E-11	.99993283E+00	702	909.998222	.29458009E-11	.99979988E+00

THE TIME AT THE START OF MSEMIS IS 81.600

INITIAL LAYER 1 FINAL LAYER 10

FILE 27 MERGED WITH FILE 28 ONTO FILE 26 WITH XTYPE= -1.0000

LOCATION	WAVENUMBER	MS EMISSION	MS TRANS	LOCATION	WAVENUMBER	MS EMISSION	MS TRANS
1	900.000000	.57584744E-11	.99998150E+00	1404	902.217086	.57327788E-11	.99997843E+00
2	900.001580	.57584743E-11	.99998151E+00	1405	902.218667	.57326470E-11	.99997781E+00
3	900.003160	.57584742E-11	.99998152E+00	1406	902.220247	.57325340E-11	.99997702E+00
4	900.004741	.57584739E-11	.99998152E+00	1407	902.221827	.57324375E-11	.99997585E+00
5	900.006321	.57584736E-11	.99998153E+00	1408	902.223407	.57323600E-11	.99997427E+00
1	902.224988	.57325381E-11	.99997183E+00	2396	906.009679	.56924400E-11	.99998023E+00
2	902.226568	.57325073E-11	.99996859E+00	2397	906.011259	.56924162E-11	.99998025E+00
3	902.228148	.57324870E-11	.99996401E+00	2398	906.012840	.56923970E-11	.99998026E+00
4	902.229728	.57324950E-11	.99995915E+00	2399	906.014420	.56923659E-11	.99998027E+00
5	902.231309	.57325010E-11	.99995669E+00	2400	906.016000	.56923014E-11	.99998028E+00
1	906.017590	.56922933E-11	.99998028E+00	2396	909.802272	.56585555E-11	.99998004E+00
2	906.019160	.56920808E-11	.99998029E+00	2397	909.80[illegible]852	.56583013E-11	.99998004E+00
3	906.020741	.56918767E-11	.99998029E+00	2398	909.805432	.56580286E-11	.99998004E+00
4	906.022321	.56917602E-11	.99998030E+00	2399	909.807012	.56577543E-11	.99998004E+00
5	906.023901	.56916604E-11	.99998031E+00	2400	909.808593	.56574848E-11	.99998004E+00
1	909.810173	.56573414E-11	.99998002E+00	117	909.993481	.56642050E-11	.99997926E+00
2	909.811753	.56570787E-11	.99998002E+00	118	909.995062	.56642073E-11	.99997912E+00
3	909.813333	.56568237E-11	.99998002E+00	119	909.996642	.56642233E-11	.99997897E+00
4	909.814914	.56565696E-11	.99998002E+00	120	909.998222	.56642056E-11	.99997880E+00
5	909.816494	.56563255E-11	.99998002E+00	121	909.999802	.56639858E-11	.99997858E+00

THE TIME AT THE END OF MSEMIS IS 81.780
.180 SECS WERE REQUIRED FOR THIS MERGE

TABLE B-2 (Cont.)

THE TIME AT THE END OF SRCFCN IS 81.781
.620 SECS WERE REQUIRED FOR THIS MERGE

FLXDWN - LAYER 6 WITH 1 PANELS

LOCATION	WAVENUMBER	COMP FLUX DN	COMP REFLECT DN
1	900.000000	.13209032E-07	.27566912E-05
2	900.010667	.13151401E-07	.27566965E-05
3	900.021333	.131281[illegible]-07	.27566991E-05
4	900.032000	.131245[illegible]-07	.27566994E-05
5	900.042667	.1313289[illegible]-07	.27566983E-05

LOCATION	WAVENUMBER	TOTAL FLUX UP	TOTAL FLUX DN
1	900.000000	.29938036E-04	.13291562E-07
2	900.010667	.29938017E-04	.13233931E-07
3	900.021333	.29937985E-04	.13210666E-07
4	900.032000	.29937939E-04	.13207103E-07
5	900.042667	.29937878E-04	.13215425E-07

LOCATION	WAVENUMBER	COMP FLUX DN	COMP REFLECT DN
934	909.952000	.15412970E-07	.28506440E-05
935	909.962667	.15903274E-07	.28505733E-05
936	909.973333	.16715744E-07	.28504565E-05
937	909.984000	.18134676E-07	.28502537E-05
938	909.994667	.20762152E-07	.28498980E-05

LOCATION	WAVENUMBER	TOTAL FLUX UP	TOTAL FLUX DN
934	909.952000	.29379766E-04	.15496721E-07
535	909.962667	.29378802E-04	.15987021E-07
936	909.973333	.29375368E-04	.16799477E-07
937	909.984000	.29368778E-04	.18218384E-07
938	909.934667	.29367228E-04	.20845846E-07

TABLE B-2 (Cont.)

THE TIME AT THE START OF SRCFCN IS 81.913

SRCFCN - LAYER 7 WITH 1 PANELS

LOCATION	WAVENUMBER	MSCAT SRC FCN	MS TRANS	LOCATION	WAVENUMBER	MSCAT SRC FCN	MS TRANS
1	900.000000	.38138560E-11	.99995972E+00	1403	909.969778	.39218621E-11	.99994100E+00
2	900.007111	.38138478E-11	.99995996E+00	1404	909.976889	.39214678E-11	.99993625E+00
3	900.014222	.38138410E-11	.99996012E+00	1405	909.984000	.39364268E-11	.99992983E+00
4	900.021333	.38138362E-11	.99996022E+00	1406	909.991111	.39365967E-11	.99992242E+00
5	900.028444	.38138318E-11	.99996025E+00	1407	909.998222	.39367803E-11	.99991058E+00

THE TIME AT THE START OF MSEMIS IS 82.199

INITIAL LAYER 1 FINAL LAYER 10

FILE 27 MERGED WITH FILE 26 ONTO FILE 28 WITH XTYPE= -.78571

LOCATION	WAVENUMBER	MS EMISSION	MS TRANS	LOCATION	WAVENUMBER	MS EMISSION	MS TRANS
1	900.000000	.95720985E-11	.99998150E+00	1404	902.217086	.95642573E-11	.99997843E+00
2	900.001580	.95720972E-11	.99998151E+00	1405	902.218667	.95641690E-11	.99997781E+00
3	900.003160	.95720955E-11	.99998152E+00	1406	902.220247	.95641641E-11	.99997702E+00
4	900.004741	.95720936E-11	.99998152E+00	1407	902.221827	.95641979E-11	.99997585E+00
5	900.006321	.95720916E-11	.99998153E+00	1408	902.223407	.95642521E-11	.99997427E+00
1	902.224988	.95645596E-11	.99997183E+00	2396	906.009679	.95750585E-11	.99998023E+00
2	902.226568	.95646420E-11	.99996859E+00	2397	906.011259	.95749905E-11	.99998025E+00
3	902.228148	.95647107E-11	.99996401E+00	2398	906.012840	.95749311E-11	.99998026E+00
4	902.229728	.95647849E-11	.99995915E+00	2399	906.014420	.95748635E-11	.99998027E+00
5	902.231309	.95648220E-11	.99995669E+00	2400	906.016000	.95747606E-11	.99998028E+00
1	906.017580	.95746970E-11	.99998028E+00	2396	909.802272	.95761544E-11	.99998004E+00
2	906.019160	.95744205E-11	.99998029E+00	2397	909.803852	.95757203E-11	.99998004E+00
3	906.020741	.95741492E-11	.99998029E+00	2398	909.805432	.95752676E-11	.99998004E+00
4	906.022321	.95739597E-11	.99998030E+00	2399	909.807012	.95748143E-11	.99998004E+00
5	906.023901	.95737816E-11	.99998031E+00	2400	909.808593	.95743678E-11	.99998004E+00
1	909.810173	.95740429E-11	.99998002E+00	117	909.993481	.96004071E-11	.99997926E+00
2	909.811753	.95736114E-11	.99998002E+00	118	909.995062	.96004380E-11	.99997912E+00
3	909.813333	.95731934E-11	.99998002E+00	119	909.996642	.96004778E-11	.99997897E+00
4	909.814914	.95727800E-11	.99998002E+00	120	909.998222	.96004795E-11	.99997880E+00
5	909.816494	.95723787E-11	.99998002E+00	121	909.999802	.96002656E-11	.99997858E+00

THE TIME AT THE END OF MSEMIS IS 82.376
.177 SECS WERE REQUIRED FOR THIS MERGE

THE TIME AT THE END OF SRCFCN IS 82.377
.464 SECS WERE REQUIRED FOR THIS MERGE

FLXDWN - LAYER 5 WITH 1 PANELS

LOCATION	WAVENUMBER	COMP FLUX DN	COMP REFLECT DN	LOCATION	WAVENUMBER	COMP FLUX DN	COMP REFLECT DN
1	900.000000	.29247665E-07	.65334371E-05	924	909.952000	.35365020E-07	.68185698E-05

TABLE B-2 (Cont.)

2	900.010667	.29181747E-07	.65334461E-05
3	900.021333	.29153177E-07	.65334510E-05
4	900.032000	.29153760E-07	.65334495E-05
5	900.042667	.29173211E-07	.65334435E-05

LOCATION	WAVENUMBER	TOTAL FLUX UP	TOTAL FLUX DN
1	900.000000	.29940239E-04	.29443278E-07
2	900.010667	.29940215E-04	.29377359E-07
3	900.021333	.29940180E-04	.29348789E-07
4	900.032000	.29940134E-04	.29349373E-07
5	900.042667	.29940075E-04	.29368823E-07

935	909.962667	.363[illegible]-07	.6818262[illegible]E-05
936	909.973333	.38096834E-07	.68177256E-05
937	909.984000	.40873887E-07	.68168986E-05
938	909.994667	.46112818E-07	.68153428E-05

LOCATION	WAVENUMBER	TOTAL FLUX UP	TOTAL FLUX DN
934	909.952000	.29382624E-04	.35565367E-07
935	909.962667	.29381783E-04	.36570446E-07
936	909.973333	.29378555E-04	.38297129E-07
937	909.984000	.29372324E-04	.41074116E-07
938	909.994667	.29371396E-04	.46312994E-07

TABLE B-2 (Cont.)

THE TIME AT THE START OF SRCFCN IS 82.497

SRCFCN - LAYER 6 WITH 1 PANELS

LOCATION	WAVENUMBER	MSCAT SRC FCN	MS TRANS	LOCATION	WAVENUMBER	MSCAT SRC FCN	MS TRANS
1	900.000000	.87244026E-11	.99987988E+00	934	909.952000	.89910185E-11	.99984118E+00
2	900.010667	.87243679E-11	.99988020E+00	935	909.962667	.89910937E-11	.99983397E+00
3	900.021333	.87243463E-11	.99988039E+00	936	909.973333	.89906731E-11	.99982194E+00
4	900.032000	.87243322E-11	.99988040E+00	937	909.984000	.89896950E-11	.99980071E+00
5	900.042667	.87243209E-11	.99988027E+00	938	909.994667	.89911711E-11	.99976449E+00

THE TIME AT THE START OF MSEMIS IS 82.695

INITIAL LAYER 1 FINAL LAYER 10

FILE 27 MERGED WITH FILE 28 ONTO FILE 26 WITH XTYPE= -.67391

LOCATION	WAVENUMBER	MS EMISSION	MS TRANS	LOCATION	WAVENUMBER	MS EMISSION	MS TRANS
1	900.000000	.18295351E-10	.99998150E+00	1404	902.217086	.18344543E-10	.99997843E+00
2	900.001580	.18295346E-10	.99998151E+00	1405	902.218667	.18344684E-10	.99997781E+00
3	900.003160	.18295340E-10	.99998152E+00	1406	902.220247	.18345122E-10	.99997702E+00
4	900.004741	.18295334E-10	.99998152E+00	1407	902.221827	.18345616E-10	.99997585E+00
5	900.006321	.18295327E-10	.99998153E+00	1408	902.223407	.18346127E-10	.99997427E+00
1	902.224988	.18346839E-10	.99997183E+00	2396	906.009679	.18432010E-10	.99998023E+00
2	902.226568	.18347310E-10	.99996859E+00	2397	906.011259	.18431793E-10	.99998025E+00
3	902.228148	.18347700E-10	.99996401E+00	2398	906.012840	.18431608E-10	.99998026E+00
4	902.229728	.18347934E-10	.99995915E+00	2399	906.014420	.18431413E-10	.99998027E+00
5	902.231309	.18347835E-10	.99995669E+00	2400	906.016000	.18431185E-10	.99998029E+00
1	906.017580	.18430954E-10	.99998028E+00	2396	909.802272	.18556280E-10	.99998004E+00
2	906.019160	.18430503E-10	.99998029E+00	2397	909.803852	.18555477E-10	.99998004E+00
3	906.020741	.18430049E-10	.99998029E+00	2398	909.805432	.18554660E-10	.99998004E+00
4	906.022321	.18429680E-10	.99998030E+00	2399	909.807012	.18553850E-10	.99998004E+00
5	906.023901	.18429299E-10	.99998031E+00	2400	909.808593	.18553056E-10	.99998004E+00
1	909.810173	.18552418E-10	.99998002E+00	117	909.993481	.18589186E-10	.99997926E+00
2	909.811753	.18551667E-10	.99998002E+00	118	909.995062	.18589362E-10	.99997912E+00
3	909.813333	.18550946E-10	.99998002E+00	119	909.996642	.18589440E-10	.99997897E+00
4	909.814914	.18550257E-10	.99998002E+00	120	909.998222	.18589459E-10	.99995788E+00
5	909.816494	.18549602E-10	.99998002E+00	121	909.999802	.18589247E-10	.99997858E+00

THE TIME AT THE END OF MSEMIS IS 82.873
.178 SECS WERE REQUIRED FOR THIS MERGE

THE TIME AT THE END OF SRCFCN IS 82.874
.377 SECS WERE REQUIRED FOR THIS MERGE

FLXDWN - LAYER 4 WITH 1 PANELS

LOCATION	WAVENUMBER	COMP FLUX DN	COMP REFLECT DN	LOCATION	WAVENUMBER	COMP FLUX DN	COMP REFLECT DN

TABLE B-2 (Cont.)

1	900.000000	.88119930E-07	.12044083E-04
2	900.016000	.88039891E-07	.12044091E-04
3	900.032000	.88048300E-07	.12044077E-04
4	900.048000	.88130809E-07	.12044028E-04
5	900.064000	.88268089E-07	.12043949E-04

LOCATION	WAVENUMBER	TOTAL FLUX UP	TOTAL FLUX DN
1	900.000000	.29947230E-04	.88480617E-07
2	900.016000	.29947184E-04	.88400577E-07
3	900.032000	.29947121E-04	.88408986E-07
4	900.048000	.29947036E-04	.88491432E-07
5	900.064000	.29946922E-04	.88626758E-07

622	909.936000	.10515392E-06	.12598354E-04
623	909.952000	.10628437E-06	.12597784E-04
624	909.968000	.10981413E-06	.12595710E-04
625	909.984000	.11700031E-06	.12591612E-04
626	910.000000	.12759827E-06	.12585609E-04

LOCATION	WAVENUMBER	TOTAL FLUX UP	TOTAL FLUX DN
622	909.936000	.29390568E-04	.10552420E-06
623	909.952000	.29391309E-04	.10665464E-06
624	909.968000	.29389763E-04	.11018432E-06
625	909.984000	.29383582E-04	.11737029E-06
626	910.000000	.29380825E-04	.12796805E-06

TABLE B-2 (Cont.)

THE TIME AT THE START OF SRCFCN IS 82.972

SRCFCN - LAYER 5 WITH 1 PANELS

LOCATION	WAVENUMBER	MSCAT SRC FCN	MS TRANS
1	900.000000	.18681305E-10	.99956378E+00
2	900.010667	.18681229E-10	.99956401E+00
3	900.021333	.18681176E-10	.99956415E+00
4	900.032000	.18681155E-10	.99956404E+00
5	900.042667	.18681152E-10	.99956374E+00
934	909.952000	.19254448E-10	.99944725E+00
935	909.962667	.19255487E-10	.99943312E+00
936	909.973333	.19256124E-10	.99940801E+00
937	909.984000	.19256715E-10	.99937671E+00
938	909.994667	.19262031E-10	.99929896E+00

THE TIME AT THE START OF MSEMIS IS 83.177

INITIAL LAYER 1 FINAL LAYER 10

FILE 27 MERGED WITH FILE 26 ONTO FILE 28 WITH XTYPE= -.67391

LOCATION	WAVENUMBER	MS EMISSION	MS TRANS
1	900.000000	.36968676E-10	.99998150E+00
2	900.001580	.36968662E-10	.99998151E+00
3	900.003160	.36968646E-10	.99998152E+00
4	900.004741	.36968628E-10	.99998152E+00
5	900.006321	.36968611E-10	.99998153E+00
1	902.224988	.37162933E-10	.99997183E+00
2	902.226568	.37164094E-10	.99996859E+00
3	902.228148	.37165025E-10	.99996401E+00
4	902.229728	.37165534E-10	.99995915E+00
5	902.231309	.37165272E-10	.99995669E+00
1	906.017580	.37398808E-10	.99998028E+00
2	906.019160	.37397863E-10	.99998029E+00
3	906.020741	.37396909E-10	.99998029E+00
4	906.022321	.37396063E-10	.99998030E+00
5	906.023901	.37395157E-10	.99998031E+00
1	909.810173	.37779242E-10	.99998002E+00
2	909.811753	.37778292E-10	.99998002E+00
3	909.813333	.37777410E-10	.99998002E+00
4	909.814914	.37776655E-10	.99998002E+00
5	909.816494	.37775965E-10	.99998002E+00
1404	902.217086	.37156098E-10	.99997843E+00
1405	902.218667	.37157154E-10	.99997781E+00
1406	902.220247	.37158598E-10	.99997702E+00
1407	902.221827	.37160058E-10	.99997585E+00
1408	902.223407	.37161468E-10	.99997427E+00
2396	906.009679	.37402055E-10	.99998023E+00
2397	906.011259	.37401360E-10	.99998025E+00
2398	906.012840	.37400764E-10	.99998026E+00
2399	906.014420	.37400156E-10	.99998027E+00
2400	906.016000	.37399528E-10	.99998028E+00
2396	909.802272	.37784598E-10	.99998004E+00
2397	909.803852	.37783412E-10	.99998004E+00
2398	909.805432	.37782264E-10	.99998004E+00
2399	909.807012	.37781155E-10	.99998004E+00
2400	909.808593	.37780096E-10	.99998004E+00
117	909.993481	.37837796E-10	.99997926E+00
118	909.995062	.37839412E-10	.99997912E+00
119	909.996642	.37838624E-10	.99997897E+00
120	909.998222	.37838703E-10	.99997888E+00
121	909.999802	.37838498E-10	.99997858E+00

THE TIME AT THE END OF MSEMIS IS 83.356
.179 SECS WERE REQUIRED FOR THIS MERGE

THE TIME AT THE END OF SRCFCN IS 83.357
.385 SECS WERE REQUIRED FOR THIS MERGE

FLXDWN - LAYER 3 WITH 1 PANELS

LOCATION	WAVENUMBER	COMP FLUX DN	COMP REFLECT DN
1	900.000000	.21915036E-06	.24916381E-04
622	909.936000	.37502655E-06	.26850061E-04

TABLE B-2 (Cont.)

2	9ØØ.Ø16ØØØ	.31911550E-Ø6	.24916322E-Ø4
3	9ØØ.Ø32ØØØ	.31918874E-Ø6	.2491621ØE-Ø4
4	9ØØ.Ø48ØØØ	.31937357E-Ø6	.249160Ø7E-Ø4
5	9ØØ.[illegible]64ØØØ	.31966171E-Ø6	.249157ØØE-Ø4

LOCATION	WAVENUMBER	TOTAL FLUX UP	TOTAL FLUX DN
1	9ØØ.ØØØØØØ	.29967594E-Ø4	.319897Ø5E-Ø6
2	9ØØ.Ø16ØØØ	.29967541E-Ø4	.31986218E-Ø6
3	9ØØ.Ø32ØØØ	.29967493E-Ø4	.31993541E-Ø6
4	9ØØ.Ø48ØØØ	.29967413E-Ø4	.32Ø12Ø23E-Ø6
5	9ØØ.Ø64ØØØ	.29967323E-Ø4	.32Ø4Ø836E-Ø6

623	9Ø9.952ØØØ	.37595785E-Ø6	.26Ø498Ø4E-Ø4
624	9Ø9.968ØØØ	.3821Ø363E-Ø6	.26Ø435Ø4E-Ø4
625	9Ø9.984ØØØ	.394ØØ693E-Ø6	.26Ø3Ø493E-Ø4
626	91Ø.ØØØØØØ	.41222Ø15E-Ø6	.26Ø1347ØE-Ø4

LOCATION	WAVENUMBER	TOTAL FLUX UP	TOTAL FLUX DN
622	9Ø9.936ØØØ	.29414985E-Ø4	.37579292E-Ø6
623	9Ø9.952ØØØ	.29415851E-Ø4	.37672412E-Ø6
624	9Ø9 [illegible]Ø	.29414855E-Ø4	.3828697ØE-Ø6
625	9Ø9 [illegible]Ø	.294Ø9732E-Ø4	.39557248E-Ø6
626	91Ø. [illegible]Ø	.294Ø8637E-Ø4	.41298516E-Ø6

TABLE B-2 (Cont.)

THE TIME AT THE START OF SRCFCN IS 83.447

SRCFCN - LAYER 4 WITH 1 PANELS

LOCATION	WAVENUMBER	MSCAT SRC FCN	MS TRANS
1	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	.99951136E+00
3	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]
622	909.936000	.28546398E-10	.99818147E+00
623	909.952000	.28548671E-10	.99817078E+00
624	909.968000	.28554577E-10	.99812582E+00
625	909.984000	.28563880E-10	.99803641E+00
626	910.000000	.28582643E-10	.99790654E+00

THE TIME AT THE START OF MSEMIS IS 83.587

[illegible] LAYER 1 FINAL LAYER 10

FILE [illegible] MERGED WITH FILE 28 ONTO FILE 26 WITH XTV,E= -.68959

LOCATION	WAVENUMBER	MS EMISSION	MS TRANS
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	.99999151E+00
[illegible]	[illegible]	[illegible]	.99999152E+00
[illegible]	[illegible]	[illegible]	.99999152E+00
[illegible]	[illegible]	[illegible]	.99999153E+00
[illegible]	[illegible]	.65219941E-10	[illegible]
[illegible]	[illegible]	[illegible]	.99995859E+00
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	.65822529E-10	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	.99998020E+00
[illegible]	[illegible]	.65457964E-10	.99998025E+00
[illegible]	[illegible]	[illegible]	.99998029E+00
[illegible]	[illegible]	[illegible]	.99998030E+00
[illegible]	[illegible]	.65478695E-10	.99998031E+00
[illegible]	[illegible]	[illegible]	.99998002E+00
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	.99998002E+00
[illegible]	[illegible]	[illegible]	.99998002E+00
[illegible]	[illegible]	[illegible]	.99998002E+00
1404	902.217086	.65003833E-10	.99997843E+00
1405	902.218667	.65006959E-10	.99997781E+00
1406	902.220247	.65010347E-10	.99997702E+00
1407	902.221827	.65013596E-10	.99997585E+00
1408	902.223407	.650[illegible]453E-10	.99997427E+00
2396	906.009679	.65[illegible]9E-10	.99998023E+00
2397	906.011259	.654[illegible]30E-10	.99998025E+00
2398	906.012848	.65490083E-10	.99998026E+00
2399	906.014420	.65489685E-10	.99998027E+00
2400	906.016000	.65487310E-10	.99998028E+00
2396	909.882272	.66263248E-10	.99998004E+00
2397	909.883852	.66262761E-10	.99998004E+00
2398	909.885432	.66262368E-10	.99998004E+00
2399	909.887012	.66262077E-10	.99998004E+00
2400	909.888593	.66262080E-10	.99998004E+00
117	909.993481	.66335989E-10	.99997926E+00
118	909.995062	.66339014E-10	.99997912E+00
119	909.996642	.66339567E-10	.99997897E+00
120	909.998222	.66340093E-10	.99997880E+00
121	909.999802	.66341822E-10	.99997858E+00

THE TIME AT THE END OF MSEMIS IS 83.756
[illegible] SECS WERE REQUIRED FOR THIS MERGE

THE TIME AT THE END OF SRCFCN IS 83.757
[illegible] SECS WERE REQUIRED FOR THIS MERGE

FLUXDN - LAYER 2 WITH 1 PANELS

LOCATION	WAVENUMBER	COMP FLUX DN	COMP REFLECT DN	LOCATION	WAVENUMBER	COMP FLUX DN	COMP REFLECT DN

TABLE B-2 (Cont.)

414	909.912000	.14284815E-05	.17406414E-02
415	909.936000	.14097454E-05	.17415509E-02
416	909.960000	.14120510E-05	.17416069E-02
417	909.984000	.14396761E-05	.17407561E-02
418	910.008000	.14752609E-05	.17404272E-02

LOCATION	WAVENUMBER	TOTAL FLUX UP	TOTAL FLUX DN
414	909.912000	.29482354E-04	.14797997E-05
415	909.936000	.29485773E-04	.14610964E-05
416	909.960000	.29486549E-04	.14634050E-05
417	909.984000	.29484630E-04	.14910016E-05
418	910.008000	.29480375E-04	.15265693E-05

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

LOCATION	WAVENUMBER	TOTAL FLUX UP	TOTAL FLUX DN
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	.12951582E-05

TABLE B-2 (Cont.)

THE TIME AT THE START OF SRCFCN IS 83.832

SRCFCN - LAYER 3 WITH 1 PANELS

LOCATION	WAVENUMBER	MSCAT SRC FCN	MS TRANS
1	900.000000	.67935670E-10	.99454345E+00
2	900.016000	.67935679E-10	.99454241E+00
3	900.032000	.67936271E-10	.99454089E+00
4	900.048000	.67936898E-10	.99453844E+00
5	900.064000	.67939133E-10	.99453486E+00
622	909.936000	.70413373E-10	.99349759E+00
623	909.952000	.70415233E-10	.99350208E+00
624	909.968000	.70443149E-10	.99343812E+00
625	909.984000	.70493953E-10	.99330323E+00
626	910.000000	.70565313E-10	.99313598E+00

THE TIME AT THE START OF MSEMIS IS 83.971

INITIAL LAYER 1 FINAL LAYER 10

FILE 27 MERGED WITH FILE 26 ONTO FILE 28 WITH XTYPE= -.60959

LOCATION	WAVENUMBER	MS EMISSION	MS TRANS
[illegible]	900.000000	.13215969E-09	.99998150E+00
[illegible]	[illegible]	.13215965E-09	.99998151E+00
[illegible]	[illegible]	.13215962E-09	.99998152E+00
4	900.002741	.13215957E-09	.99998152E+00
5	[illegible]	.13215953E-09	.99998153E+00
[illegible]	[illegible]	[illegible]	.99997193E+00
[illegible]	[illegible]	[illegible]	.99996859E+00
[illegible]	[illegible]	[illegible]	.99996481E+00
4	[illegible]	[illegible]	.99995915E+00
5	[illegible]	.13337129E-09	.99995669E+00
1	[illegible]	[illegible]	.99998028E+00
2	[illegible]	[illegible]	.99998029E+00
3	906.020741	.13463244E-09	.99998029E+00
4	906.022321	.13463253E-09	.99998030E+00
5	906.023901	[illegible]	.99998031E+00
[illegible]	[illegible]	.13647263E-09	.99998002E+00
[illegible]	[illegible]	.13648188E-09	.99998002E+00
[illegible]	[illegible]	.13649963E-09	.99998002E+00
4	909.814914	.13649940E-09	.99998002E+00
5	909.816494	.13650648E-09	.99998002E+00
1404	902.217866	.13331778E-09	.99997843E+00
1405	902.218667	.13332792E-09	.99997781E+00
1406	902.220247	.13333791E-09	.99997702E+00
1407	902.221827	.13334726E-09	.99997585E+00
1408	902.223407	.13335512E-09	.99997427E+00
2396	906.009679	[illegible]	.99998023E+00
2397	906.011259	.13463619E-09	.99998025E+00
2398	906.012840	.13463511E-09	.99998026E+00
2399	906.014420	.13463449E-09	.99998027E+00
2400	906.016000	.13463426E-09	.99998028E+00
2396	909.802272	.13642296E-09	.99998004E+00
2397	909.803852	.13643302E-09	.99998004E+00
2398	909.805432	.13644310E-09	.99998004E+00
2399	909.807012	.13645311E-09	.99998004E+00
2400	909.808593	.13646293E-09	.99998004E+00
117	909.993461	.13642408E-09	.99997926E+00
118	909.995032	.13643207E-09	.99997912E+00
119	909.996642	.13643923E-09	.99997897E+00
120	909.998222	.13644574E-09	.99997880E+00
121	909.999802	.13645133E-09	.99997858E+00

THE TIME AT THE END OF MSEMIS IS 84.149
.177 SECS WERE REQUIRED FOR THIS MERGE

THE TIME AT THE END OF SRCFCN IS 84.149
.316 SECS WERE REQUIRED FOR THIS MERGE

FLXDWN - LAYER 1 WITH 1 PANELS

LOCATION	WAVENUMBER	COMP FLUX DN	COMP REFLECT DN
1	900.000000	.44390270E-05	.14217353E-01
414	909.912000	.49279707E-05	.14355144E-01

TABLE B-2 (Cont.)

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	.14216249E-01
[illegible]	[illegible]	[illegible]	[illegible]

LOCATION	WAVENUMBER	TOTAL FLUX UP	TOTAL FLUX DN
[illegible]	[illegible]	[illegible]	.43589695E-05
[illegible]	[illegible]	[illegible]	.48696030E-05
[illegible]	[illegible]	[illegible]	.48705174E-05
[illegible]	[illegible]	[illegible]	.48720423E-05
[illegible]	[illegible]	[illegible]	[illegible]

415	909.936000	.48813084E-05	.14375567E-01
416	909.960000	.48736931E-05	.14381794E-01
417	909.984000	.49091114E-05	.14373579E-01
418	910.008000	.4972495[illegible]E-05	.14360448E-01

LOCATION	WAVENUMBER	TOTAL FLUX UP	TOTAL FLUX DN
414	909.912000	.29716525E-04	.53545557E-05
415	909.936000	.29718101E-04	.53085230E-05
415	909.960000	.29718685E-04	.53011011E-05
417	909.984000	.29718399E-04	.53362698E-05
419	910.008000	.29716577E-04	.53992388E-05

TABLE B-2 (Cont.)

THE TIME AT THE START OF SRCFCN IS 84.215

SRCFCN - LAYER 2 WITH 1 PANELS

LOCATION	WAVENUMBER	MSCAT SRC FCN	MS TRANS	LOCATION	WAVENUMBER	MSCAT SRC FCN	MS TRANS
1	900.000000	.10410644E-07	.97391271E+00	414	909.912000	.11118136E-07	.97251476E+00
2	900.024000	.10411289E-07	.97390796E+00	415	909.936000	.11066837E-07	.97080506E+00
3	900.048000	.10412495E-07	.97390129E+00	416	909.960000	.11062850E-07	.97082385E+00
4	900.072000	.10414320E-07	.97389154E+00	417	909.984000	.11112896E-07	.97055489E+00
5	900.096000	.10415712E-07	.97387869E+00	418	910.008000	.11196381E-07	.97014591E+00

THE TIME AT THE START OF MSEMIS IS 84.318

INITIAL LAYER 1 FINAL LAYER 10

FILE 27 MERGED WITH FILE 28 ONTO FILE 26 WITH XTYPE= -.57049

LOCATION	WAVENUMBER	MS EMISSION	MS TRANS	LOCATION	WAVENUMBER	MS EMISSION	MS TRANS
1	900.000000	.10539356E-07	.99998150E+00	1404	902.217086	.10839479E-07	.99997843E+00
2	900.001580	.10539391E-07	.99998151E+00	1405	902.218667	.10844497E-07	.93997781E+00
3	900.003160	.10539405E-07	.99998152E+00	1406	902.220247	.10848630E-07	.99997702E+00
4	900.004741	.10539436E-07	.99998152E+00	1407	902.221827	.10853226E-07	.99997585E+00
5	900.006321	.10539465E-07	.99998153E+00	1408	902.223407	.10856950E-07	.99997427E+00
1	902.224989	.10551011E-07	.99997183E+00	2396	906.009679	.11305508E-07	.99998023E+00
2	902.226569	.10554229E-07	.99996859E+00	2397	906.011259	.11310686E-07	.99998025E+00
3	902.228149	.10557647E-07	.99995401E+00	2398	906.012840	.11316401E-07	.99998026E+00
4	902.229729	.10570572E-07	.99995915E+00	2399	906.014420	.11321728E-07	.99998027E+00
5	902.231309	.10572929E-07	.99995669E+00	2400	906.016000	.11328445E-07	.99998028E+00
1	905.017582	.11334637E-07	.99998028E+00	2396	909.802272	.11519253E-07	.99998004E+00
2	905.019162	.11342358E-07	.99998029E+00	2397	909.803852	.11530256E-07	.99998004E+00
3	905.020741	.11350547E-07	.99998029E+00	2398	909.805432	.11544068E-07	.99998004E+00
4	905.022321	.11359184E-07	.99998030E+00	2399	909.807012	.11557589E-07	.99998004E+00
5	905.023901	.11367492E-07	.99998031E+00	2400	909.808593	.11568876E-07	.99998004E+00
1	909.810173	.11591607E-07	.99998002E+00	117	909.993481	.11281208E-07	.99997926E+00
2	909.811753	.11592077E-07	.99998002E+00	118	909.995062	.11286600E-07	.99997912E+00
3	909.813333	.11602693E-07	.99998002E+00	119	909.996642	.11292795E-07	.99997897E+00
4	909.814914	.11614576E-07	.99998002E+00	120	909.998222	.11297996E-07	.99997880E+00
5	909.816494	.11622418E-07	.99998002E+00	121	909.999802	.11303896E-07	.99997858E+00

THE TIME AT THE END OF MSEMIS IS 84.486
[illegible] SECS WERE REQUIRED FOR THIS MERGE

THE TIME AT THE END OF SRCFCN IS 84.487
[illegible] SECS WERE REQUIRED FOR THIS MERGE

FLXDN - LAYER 0 WITH 1 PANELS

LOCATION	WAVENUMBER	COMP FLUX DN	COMP REFLECT DN	LOCATION	WAVENUMBER	COMP FLUX DN	COMP REFLECT DN
1	900.000000	.44290230E-05	.14217353E-01	414	909.912000	.49279707E-05	.14355144E-01

TABLE B-2 (Cont.)

2	9ØØ.Ø24ØØØ	.44296658E-Ø5	.14217Ø54E-Ø1
3	9ØØ.Ø48ØØØ	.44426917E-Ø5	.14216688E-Ø1
4	9ØØ.Ø72ØØØ	.4442[illegible]E-Ø5	.14216249E-Ø1
5	9ØØ.Ø96ØØØ	.44444[illegible]94E-Ø5	.14215699E-Ø1

LOCATION	WAVENUMBER	TOTAL FLUX UP	TOTAL FLUX DN
1	9ØØ.ØØØØØØ	.3Ø843Ø33E-Ø4	.48775293E-Ø5
2	9ØØ.Ø24ØØØ	.3Ø843Ø33E-Ø4	.48781629E-Ø5
3	9ØØ.Ø48ØØØ	.3Ø843Ø33E-Ø4	.48791775E-Ø5
4	9ØØ.Ø72ØØØ	.3Ø843Ø33E-Ø4	.488Ø6Ø27E-Ø5
5	9ØØ.Ø96ØØØ	.3Ø843Ø33E-Ø4	.48824747E-Ø5

415	9Ø9.936ØØØ	.48813Ø84E-Ø5	.14375567E-Ø1
416	9Ø9.96ØØØØ	.48736931E-Ø5	.14381794E-Ø1
417	9Ø9.984ØØØ	.49Ø91114E-Ø5	.14373579E-Ø1
418	91Ø.ØØØØØØ	.49724955E-Ø5	.1436Ø448E-Ø1

LOCATION	WAVENUMBER	TOTAL FLUX UP	TOTAL FLUX DN
414	9Ø9.912ØØØ	.3Ø34Ø87ØE-Ø4	.53635182E-Ø5
415	9Ø9.936ØØØ	.3Ø34Ø87ØE-Ø4	.53174756E-Ø5
416	9Ø9.96ØØØØ	.3Ø34Ø87ØE-Ø4	.531ØØ493E-Ø5
417	9Ø9.984ØØØ	.3Ø34Ø87ØE-Ø4	.53452183E-Ø5
418	91Ø.ØØØØØØ	.3Ø34Ø87ØE-Ø4	.54Ø82Ø4ØE-Ø5

TABLE B-2 (Cont.)

THE TIME AT THE START OF SRCFCN IS 84.549

SRCFCN LAYER 1 WITH 1 PANELS

LOCATION	WAVENUMBER	MSCAT SRC FCN	MS TRANS
1	900.000000	.10879261E-05	.88602463E+00
2	900.024000	.10990036E-05	.88601474E+00
3	900.048000	[illegible]1321E-06	.88502271E+00
4	900.072000	.10893095E-06	.88598042E+00
5	[illegible]	.10855156E-06	.88597053E+00

LOCATION	WAVENUMBER	MSCAT SRC FCN	MS TRANS
414	909.912000	.11658002E-06	.87680000E+00
415	909.936000	.11600859E-06	.87746871E+00
416	909.960000	.11502319E-06	.87767792E+00
417	909.984000	.11637694E-06	.87742118E+00
418	910.008000	.11722572E-06	.97668722E+00

THE TIME AT THE START OF MSEMIS IS 84.643

INITIAL LAYER 1 FINAL LAYER 10

FILE 27 MERGED WITH FILE 26 ONTO FILE 28 WITH XTYPE= -.57048

LOCATION	WAVENUMBER	MS EMISSION	MS TRANS
[illegible]	902.200000	.11813274E-06	.99998150E+00
[illegible]	902.201580	.11813128E-06	.99998151E+00
[illegible]	902.203160	.11813140E-06	.99998152E+00
4	902.204741	.11813102E-05	.99998152E+00
5	902.206321	.11812220E-06	.99998153E+00
1	[illegible]	.12140399E-06	.99997182E+00
2	902.226550	.12149612E-05	.99996259E+00
3	902.228149	.12157110E-06	.99996401E+00
4	902.229728	.12156233E-06	.99995915E+00
5	902.231289	.12159588E-06	.99995669E+00
1	905.017580	.12754372E-06	.99998028E+00
2	905.019160	.12764602E-06	.99998029E+00
3	905.020741	.12775478E-06	.99998029E+00
4	905.022321	.12785322E-06	.99998030E+00
5	905.023901	.12797421E-06	.99998031E+00
1	909.910173	.13026473E-06	.99998002E+00
2	909.911753	.13037754E-05	.99998002E+00
3	909.913333	.13050256E-06	.99998002E+00
4	909.914914	.13061952E-06	.99998002E+00
5	909.916494	.13070360E-06	.99998002E+00

LOCATION	WAVENUMBER	MS EMISSION	MS TRANS
1404	902.217086	.12125074E-06	.99997843E+00
1405	902.218667	.12130209E-06	.99997781E+00
1406	902.220247	.12134083E-06	.99997702E+00
1407	902.221827	.12138638E-06	.99997585E+00
1408	902.223407	.12142320E-06	.99997427E+00
2396	906.009679	.12714737E-06	.99998023E+00
2397	906.011259	.12721977E-06	.99998025E+00
2398	906.012840	.12729841E-06	.99998026E+00
2399	906.014420	.12737082E-06	.99998027E+00
2400	906.016000	.12746118E-06	.99998028E+00
2396	909.802272	.12957956E-06	.99998004E+00
2397	909.803852	.12970975E-06	.99998004E+00
2398	909.805432	.12985930E-06	.99998004E+00
2399	909.807012	.13000550E-06	.99998004E+00
2400	909.808593	.13012740E-06	.99998004E+00
117	909.993481	.12663364E-06	.99997926E+00
118	909.995062	.12669263E-06	.99997912E+00
119	909.996642	.12676055E-06	.99997897E+00
120	909.998222	.12681766E-06	.99997880E+00
121	909.999802	.12688259E-06	.99997858E+00

THE TIME AT THE END OF MSEMIS IS 84.820
.177 SECS WERE REQUIRED FOR THIS MERGE

THE TIME AT THE END OF SRCFCN IS 84.821
.272 SECS WERE REQUIRED FOR THIS MERGE

THE TIME AT THE END OF FLXDWN IS 84.822
1.242 SECS WERE REQUIRED FOR THIS MERGE

THE TIME AT THE START OF TLEMIS IS 84.823

TABLE B-2 (Cont.)

INITIAL LAYER 1 FINAL LAYER 10

FILE 29 MERGED WITH FILE 12 ONTO FILE 11 WITH XTYPE= 0.

LOCATION	WAVENUMBER	RADIANCE	TRANSMITTANCE
1	902.000000	.91543974E-06	.85617046E+00
2	902.001580	.9154424[illegible]E-06	.85617027E+00
3	902.003160	.915447[illegible]E-06	.85616992E+00
4	902.004741	.91545426E-06	.85616943E+00
5	902.006321	.91546127E-06	.85616885E+00
1	902.224999	.95557446E-06	.85059627E+00
2	902.226569	.956098[illegible]E-06	.85051972E+00
3	902.228149	.95564[illegible]12E-06	.85044998E+00
4	902.229729	.95574888E-06	.85039297E+00
5	902.231309	.95701516E-06	.85035581E+00
1	905.017580	.1042205[illegible]E-05	.84082274E+00
2	905.019160	.10436936E-05	.84067250E+00
3	905.020741	.10452506E-05	.84051434E+00
4	905.022321	.10469701E-05	.84034759E+00
5	905.023901	.10455892E-05	.84017171E+00
1	909.010173	.10713305E-05	.83649006E+00
2	909.011753	.10738573E-05	.83628309E+00
3	909.013333	.10747121E-05	.83600537E+00
4	909.014914	.10762685E-05	.83589666E+00
5	909.016494	.10776837E-05	.83572059E+00

THE TIME AT THE END OF TLEMIS IS 84.920
[illegible] SECS WERE REQUIRED FOR THIS MERGE

TIME LEAVING CASCODE 84.9250 TOTAL 13.2210

LOCATION	WAVENUMBER	RADIANCE	TRANSMITTANCE
1404	902.217086	.95298365E-06	.85102450E+00
1405	902.218667	.95350243E-06	.85093402E+00
1406	902.220247	.95406210E-06	.85084592E+00
1407	902.221827	.95453889E-06	.85076012E+00
1408	902.223407	.95509917E-06	.85067694E+00
2396	905.009679	.10357183E-05	.84147561E+00
2397	906.011259	.10368826E-05	.84136043E+00
2398	906.012840	.10381255E-05	.84123647E+00
2399	906.014420	.10394271E-05	.84110468E+00
2400	906.016000	.10408024E-05	.84096613E+00
2396	909.802272	.10616034E-05	.83762952E+00
2397	909.803852	.10636313E-05	.83739263E+00
2398	909.805432	.10656460E-05	.83715874E+00
2399	909.807012	.10676136E-05	.83692923E+00
2400	909.808593	.10695003E-05	.83670569E+00
117	909.993481	.10156897E-05	.84244313E+00
118	909.995062	.10157522E-05	.84244148E+00
119	909.996642	.10158244E-05	.84243948E+00
120	909.998222	.10158919E-05	.84243462E+00
121	909.999802	.10159572E-05	.84243443E+00

Appendix C

EXAMPLES OF LOWTRAN OUTPUT

Four cases are included as tests for LOWTRAN with multiple scattering. The input cards for the four cases are listed in Table C-1 and the listing of the file OUTPUT (TAPE 6) is in Tables C-2 - C-5. The next section will discuss the output for case 1. Only those details which differ from the standard LOWTRAN output will be discussed.

C.1 Case 1: Thermal Scattering of Downward Radiance

This case demonstrates the new multiple scattering calculation for thermal radiance. The parameters selected for this case are as follows: the atmospheric profile is the 1962 U.S. Standard and the boundary layer aerosol model is RURAL with 5 km meteorological range. The path is a slant path from the ground to 20 km with a zenith angle at the ground of 0.0 degrees.

The output for this case shown in Table C-2 will now be described. The first difference is in CARD 1, which now contains another quantity, IMULT. IMULT is the last variable printed on CARD 1, and is the flag for multiple scattering. When IMULT is 1, the multiple scattering features of the program will be used. A message to this effect is printed in the output directly after the message which tells the user that 'PROGRAM WILL COMPUTE RADIANCE'.

The next four pages which print out the 'ATMOSPHERIC PROFILES' and the 'REFRACTED PATH THROUGH THE ATMOSPHERE' are identical to those printed out by LOWTRAN6. The following three pages are not included in LOWTRAN6. These three pages contain the new slant path parameters for using multiple scattering followed by the refracted path used by the multiple scattering run, and the summary of the multiple scattering geometry calculation. The final page is exactly identical except that the radiance that is printed out is the multiple scattered radiance.

C.2 Case 2: Thermal Scattering of Upward Radiance

This case is directly analogous to Case 1 except that the observer is looking straight down instead of straight up. The output differences are the same as those explained for Case 1.

C.3 Case 3: Solar Scattering of Downward Radiance

Case 3 illustrates the multiple scattered solar radiance calculation. The parameters for this case are the same as those for Case 1, with the addition of the sun at 60 degrees. The output differences are the same as those listed for Case 1, excluding the final radiance output.

The final radiance output has been expanded for the solar case. Two new columns have been added. Under the column heading 'PATH SCATTERED RADIANCE', there are now three columns. These are 'TOTAL' (in both cm^{-1} and microns) and 'S SCAT' (in cm^{-1}). TOTAL is the total path scattered radiance, containing both single and multiple scattered contributions. S SCAT is the single scattered part of the total path scattered radiance. This S SCAT is the quantity that LOWTRAN would provide under the 'PATH SCATTERED' heading if the user were to run LOWTRAN without multiple scattering. Likewise under the header 'GROUND REFLECTED RADIANCE' there are now three columns. These are TOTAL (in both cm^{-1} and microns) and 'DIRECT' (in cm^{-1}). TOTAL is the total ground reflected contribution to the radiance, containing both scattered and direct contributions. DIRECT is the direct ground reflected part of the total reflected radiance. The DIRECT term is the quantity that LOWTRAN would provide under the GROUND REFLECTED heading if the user were to run LOWTRAN without multiple scattering. The significance of the S SCAT and the DIRECT terms is that the user can run one case of multiple scattering and by comparing these quantities to the total quantities can determine the relative importance of multiple scattering for that case. This will allow the user to decide more easily whether or not multiple scattering has a significant contribution for that particular case.

C.4 Case 4: Solar Scattering of Upward Radiance

This case is directly analogous to Case 3 except that the observer is looking straight down instead of straight up. The output differences are the same as those explained for Case 3.

TABLE C-1

INPUT CARDS FOR THE FOUR LOWTRAN TEST CASES

Test Case 1

```
     6    2    1    Ø    Ø    Ø    Ø    Ø      ØØØ.Ø     Ø.ØØ   Ø1
     2    Ø    Ø    Ø    Ø    Ø     Ø.ØØØ     Ø.ØØØ    Ø.ØØØ   Ø.ØØØ
        Ø.Ø       2Ø.Ø        Ø.ØØ
   85Ø.Ø     95Ø.Ø       5.Ø
  Ø
```

Test Case 2

```
     6    2    1    Ø    Ø    Ø    Ø    Ø      ØØØ.Ø     Ø.ØØ   Ø1
     2    Ø    Ø    Ø    Ø    Ø     Ø.ØØØ     Ø.ØØØ    Ø.ØØØ   Ø.ØØØ
       2Ø.Ø      ØØ.Ø     1ØØ.ØØ
   85Ø.Ø     95Ø.Ø       5.Ø
  Ø
```

Test Case 3

```
     6    2    2    Ø    Ø    Ø    Ø    Ø      ØØØ.Ø     Ø.4Ø   Ø1
     2    Ø    Ø    Ø    Ø    Ø     Ø.ØØØ     Ø.ØØØ    Ø.ØØØ   Ø.ØØØ
        Ø.Ø       2Ø.Ø        Ø.ØØ
     2    2    1    Ø
  ØØØ.Ø     6Ø.ØØ     ØØ.Ø      2Ø.Ø      ØØ.Ø      ØØ.Ø      ØØ.Ø      ØØ.Ø
 181ØØ.Ø   1626Ø.Ø      1Ø.Ø
  Ø
```

Test Case 4

```
     6    2    2    Ø    Ø    Ø    Ø    Ø      ØØØ.Ø     Ø.4Ø   Ø1
     2    Ø    Ø    Ø    Ø    Ø     Ø.ØØØ     Ø.ØØØ    Ø.ØØØ   Ø.ØØØ
       2Ø.Ø      ØØ.Ø     1ØØ.ØØ
     7    2    1    Ø
  ØØØ.Ø     6Ø.ØØ     ØØ.Ø      ØØ.Ø      ØØ.Ø      ØØ.Ø      ØØ.Ø      ØØ.Ø
 181ØØ.Ø   1826Ø.Ø      1Ø.Ø
  Ø
```

TABLE C-2

LOWTRAN OUTPUT FOR CASE 1

```
***** LOWTRAN 6 *****

CARD 1 *****    6    2    1    0    0    0    0    0      .000      .000    1

CARD 2 *****    0    0    0    0    0    0    .000      .200      .000      .000

CARD 3 *****      .000    20.000      .000      .000      .000      .000    0

CARD 4 *****   850.000   950.000     5.000

PROGRAM WILL COMPUTE RADIANCE

CALCULATIONS WILL BE DONE USING MULTIPLE SCATTERING

ATMOSPHERIC MODEL
        TEMPERATURE =    6      1962 U S STANDARD

        WATER VAPOR =    6      1962 U S STANDARD
        OZONE       =    6      1962 U S STANDARD

AEROSOL MODEL
        REGIME                    AEROSOL TYPE             PROFILE                  SEASON

        BOUNDARY LAYER (0-2 KM)   RURAL                     5.0 KM VIS AT SEA LEVEL
        TROPOSPHERE  (2-10KM)     TROPOSPHERIC             TROPOSPHERIC             SPRING-SUMMER
        STRATOSPHERE (10-30KM)    BACKGROUND STRATO        BACKGROUND STRATO        SPRING-SUMMER

        UPPER ATMOS (30-100KM)    METEORIC DUST            NORMAL

SLANT PATH, H1 TO H2
        H1    =       .000 KM
        H2    =     20.000 KM
        ANGLE =       .000 DEG
        RANGE =       .000 KM
        BETA  =       .000 DEG
        LEN   =      0

FREQUENCY RANGE
        V1 =        650.0 CM-1   (      11.76 MICROMETERS)
        V2 =        950.0 CM-1   (      10.53 MICROMETERS)
        DV =          5.0 CM-1
```

TABLE C-2 (Cont).

ATMOSPHERIC PROFILES

I	Z (KM)	P (MB)	T (K)	H2O	CO2+	O3	N2	CNTMSLF (MOL/CM2 KM)	MOL SCAT (-)	N-1 (-)	O3 (UV) (ATM CM/KM)
				(SCALED	LOWTRAN	UNITS)					
1	.00	1013.000	288.2	5.758E-01	9.285E-01	2.493E-03	7.378E-01	1.569E+20	9.475E-01	2.722E-04	2.520E-03
2	1.00	898.800	281.7	3.719E-01	7.771E-01	2.387E-03	6.010E-01	7.951E+19	8.601E-01	2.471E-04	2.520E-03
3	2.00	795.000	275.2	2.323E-01	6.474E-01	2.284E-03	4.870E-01	3.791E+19	7.788E-01	2.238E-04	2.520E-03
4	3.00	701.200	268.7	1.302E-01	5.371E-01	2.020E-03	3.927E-01	1.460E+19	7.035E-01	2.022E-04	2.333E-03
5	4.00	616.600	262.2	7.166E-02	4.435E-01	1.774E-03	3.150E-01	5.454E+18	6.340E-01	1.823E-04	2.147E-03
6	5.00	540.500	255.7	3.745E-02	3.646E-01	1.692E-03	2.513E-01	1.846E+18	5.698E-01	1.638E-04	2.147E-03
7	6.00	472.200	249.2	1.992E-02	2.982E-01	1.576E-03	1.994E-01	6.508E+17	5.108E-01	1.469E-04	2.102E-03
8	7.00	411.100	242.7	9.834E-03	2.427E-01	1.632E-03	1.572E-01	1.988E+17	4.566E-01	1.313E-04	2.287E-03
9	8.00	356.500	236.2	5.004E-03	1.963E-01	1.645E-03	1.232E-01	6.490E+16	4.069E-01	1.170E-04	2.427E-03
10	9.00	308.000	229.7	1.753E-03	1.579E-01	2.130E- [illegible]	[illegible].586E-02	9.537E+15	3.615E-01	1.040E-04	3.313E-03
11	10.00	265.000	223.3	5.894E-04	1.262E-01	2.557E-[illegible]	7.403E-02	1.460E+15	3.199E-01	9.201E-05	4.200E-03
12	11.00	227.000	216.6	2.367E-04	1.002E-01	3.493E-03	5.678E-02	3.031E+14	2.823E-01	8.118E-05	6.067E-03
13	12.00	194.000	216.7	9.075E-05	7.619E-02	4.037E-03	4.150E-02	6.170E+13	2.413E-01	6.941E-05	7.467E-03
14	13.00	165.800	216.7	3.917E-05	5.708E-02	4.028E-03	3.031E-02	1.460E+13	2.063E-01	5.932E-05	7.933E-03
15	14.00	141.700	216.7	1.787E-05	4.357E-02	4.228E-03	2.214E-02	3.180E+12	1.763E-01	5.073E-05	8.867E-03
16	15.00	121.100	216.7	1.181E-05	3.340E-02	4.388E-03	1.617E-02	2.337E+12	1.507E-01	4.333E-05	9.800E-03
17	16.00	103.500	216.7	5.587E-06	2.537E-02	4.710E-03	1.181E-02	1.677E+12	1.288E-01	3.703E-05	1.120E-02
18	17.00	88.500	216.7	6.432E-06	1.929E-02	5.161E-03	8.637E-03	1.219E+12	1.101E-01	3.166E-05	1.307E-02
19	18.00	75.650	216.7	4.726E-06	1.466E-02	5.540E-03	6.311E-03	8.726E+11	9.411E-02	2.707E-05	1.493E-02
20	19.00	64.670	216.7	4.104E-06	1.114E-02	5.691E-03	4.612E-03	8.726E+11	8.045E-02	2.314E-05	1.633E-02
21	20.00	55.290	216.7	3.564E-06	8.470E-03	5.803E-03	3.371E-03	8.726E+11	6.878E-02	1.979E-05	1.773E-02
22	21.00	47.290	217.6	3.371E-06	6.406E-03	5.447E-03	2.451E-03	1.030E+12	5.859E-02	1.685E-05	1.773E-02
23	22.00	40.470	218.6	3.168E-06	4.847E-03	5.248E-03	1.783E-03	1.219E+12	4.991E-02	1.435E-05	1.620E-02
24	23.00	34.670	219.6	3.015E-06	3.675E-03	4.802E-03	1.299E-03	1.464E+12	4.256E-02	1.224E-05	1.773E-02
25	24.00	29.720	220.6	2.803E-06	2.789E-03	4.274E-03	9.483E-04	1.677E+12	3.632E-02	1.044E-05	1.680E-02
26	25.00	25.490	221.6	2.636E-06	2.119E-03	3.792E-03	6.929E-04	1.963E+12	3.101E-02	8.918E-06	1.587E-02
27	30.00	11.970	226.5	7.612E-07	5.476E-04	1.642E-03	1.479E-04	6.508E+11	1.425E-02	4.097E-06	9.333E-03
28	35.00	5.746	236.5	1.624E-07	1.429E-04	6.674E-04	3.193E-05	1.154E+11	6.550E-03	1.884E-06	5.133E-03
29	40.00	2.871	250.4	3.549E-08	3.922E-05	2.227E-04	7.318E-06	2.023E+10	3.091E-03	8.889E-07	2.287E-03
30	45.00	1.491	264.2	9.176E-09	1.157E-05	5.881E-05	1.821E-06	4.615E+09	1.521E-03	4.375E-07	7.933E-04
31	50.00	.798	270.7	1.939E-09	3.747E-06	1.072E-05	5.027E-07	6.490E+08	7.945E-04	2.285E-07	1.867E-04
32	70.00	.055	219.7	2.406E-12	4.560E-08	8.259E-08	3.291E-09	1.014E+05	6.773E-05	1.948E-08	4.013E-06
33	100.00	.000	210.0	1.502E-16	5.420E-12	5.180E-12	1.046E-13	4.507E+00	3.861E-07	1.111E-10	2.007E-09

TABLE C-2 (Cont).

ATMOSPHERIC PROFILES

I	Z (KM)	P (MB)	T (K)	CNTMFRN MOL/CM2 KM	HNO3 ATM CM/KM	AEROSOL 1 (-)	AEROSOL 2 (-)	AEROSOL 3 (-)	AEROSOL 4 (-)	AER1*RH (-)	CIRRUS (-)	RH (PERCNT)
1	.00	1013.000	288.2	2.010E+22	.000E+00	7.700E-01	.000E+00	.000E+00	.000E+00	3.533E+01	.000E+00	4.589E+01
2	1.00	898.800	281.7	1.301E+22	.000E+00	7.700E-01	.000E+00	.000E+00	.000E+00	3.777E+01	.000E+00	4.906E+01
3	2.00	795.000	275.2	8.143E+21	.000E+00	6.210E-02	.000E+00	.000E+00	.000E+00	3.230E+00	.000E+00	5.201E+01
4	3.00	701.200	268.7	4.573E+21	.000E+00	.000E+00	3.460E-02	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
5	4.00	616.600	262.2	2.521E+21	.000E+00	.000E+00	1.850E-02	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
6	5.00	540.500	255.7	1.319E+21	.000E+00	.000E+00	9.310E-03	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
7	6.00	472.200	249.2	7.025E+20	.000E+00	.000E+00	7.710E-03	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
8	7.00	411.100	242.7	3.472E+20	.000E+00	.000E+00	6.230E-03	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
9	8.00	356.500	236.2	1.768E+20	4.059E-35	.000E+00	3.370E-03	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
10	9.00	308.000	229.7	6.023E+19	3.615E-06	.000E+00	1.820E-03	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
11	10.00	265.000	223.3	2.086E+19	1.056E-05	.000E+00	.000E+00	1.140E-03	.000E+00	.000E+00	.000E+00	.000E+00
12	11.00	227.000	216.8	8.384E+18	2.258E-05	.000E+00	.000E+00	7.990E-04	.000E+00	.000E+00	.000E+00	.000E+00
13	12.00	194.000	216.7	3.235E+18	2.896E-05	.000E+00	.000E+00	6.410E-04	.000E+00	.000E+00	.000E+00	.000E+00
14	13.00	165.800	216.7	1.345E+18	2.888E-05	.000E+00	.000E+00	5.170E-04	.000E+00	.000E+00	.000E+00	.000E+00
15	14.00	141.700	216.7	5.364E+17	2.820E-05	.000E+00	.000E+00	4.420E-04	.000E+00	.000E+00	.000E+00	.000E+00
16	15.00	121.100	216.7	3.929E+17	2.712E-05	.000E+00	.000E+00	3.950E-04	.000E+00	.000E+00	.000E+00	.000E+00
17	16.00	103.50	216.7	2.845E+17	2.446E-05	.000E+00	.000E+00	3.820E-04	.000E+00	.000E+00	.000E+00	.000E+00
18	17.00	88.500	216.7	2.074E+17	2.202E-05	.000E+00	.000E+00	4.250E-04	.000E+00	.000E+00	.000E+00	.000E+00
19	18.00	75.650	216.7	1.500E+17	1.976E-05	.000E+00	.000E+00	5.260E-04	.000E+00	.000E+00	.000E+00	.000E+00
20	19.00	64.670	216.7	1.282E+17	1.850E-05	.000E+00	.000E+00	5.810E-04	.000E+00	.000E+00	.000E+00	.000E+00
21	20.00	55.290	216.7	1.096E+17	2.063E-05	.000E+00	.000E+00	5.590E-04	.000E+00	.000E+00	.000E+00	.000E+00
22	21.00	47.290	217.6	1.019E+17	2.168E-05	.000E+00	.000E+00	5.020E-04	.000E+00	.000E+00	.000E+00	.000E+00
23	22.00	40.470	218.6	9.401E+16	2.096E-05	.000E+00	.000E+00	4.200E-04	.000E+00	.000E+00	.000E+00	.000E+00
24	23.00	34.670	219.6	8.788E+16	2.213E-05	.000E+00	.000E+00	3.000E-04	.000E+00	.000E+00	.000E+00	.000E+00
25	24.00	29.720	220.6	8.025E+16	2.179E-05	.000E+00	.000E+00	1.980E-04	.000E+00	.000E+00	.000E+00	.000E+00
26	25.00	25.490	221.6	7.414E+16	1.178E-05	.000E+00	.000E+00	1.310E-04	.000E+00	.000E+00	.000E+00	.000E+00
27	30.00	11.970	226.5	1.961E+16	3.704E-06	.000E+00	.000E+00	3.320E-05	.000E+00	.000E+00	.000E+00	.000E+00
28	35.00	5.746	236.5	3.796E+15	1.441E-07	.000E+00	.000E+00	.000E+00	1.640E-05	.000E+00	.000E+00	.000E+00
29	40.00	2.871	250.4	7.502E+14	3.091E-37	.000E+00	.000E+00	.000E+00	7.990E-06	.000E+00	.000E+00	.000E+00
30	45.00	1.491	264.7	1.764E+14	.000E+00	.000E+00	.000E+00	.000E+00	4.010E-06	.000E+00	.000E+00	.000E+00
31	50.00	.798	270.7	3.454E+13	.000E+00	.000E+00	.000E+00	.000E+00	2.100E-06	.000E+00	.000E+00	.000E+00
32	70.00	.055	219.7	3.680E+10	.000E+00	.000E+00	.000E+00	.000E+00	1.600E-07	.000E+00	.000E+00	.000E+00
33	100.00	.000	210.0	1.399E+06	.000E+00	.000E+00	.000E+00	.000E+00	9.310E-10	.000E+00	.000E+00	.000E+00

CASE 2A: GIVEN H1, H2, ANGLE

SLANT PATH PARAMETERS IN STANDARD FORM

H1	=	.000 KM
H2	=	20.000 KM
ANGLE	=	.000 DEG

TABLE C-2 (Cont).

PHI = 180.000 DEG
HMIN = .000 KM
LEN = 0

TABLE C-2 (Cont).

CALCULATION OF THE REFRACTED PATH THROUGH THE ATMOSPHERE

I	ALTITUDE FROM (KM)	ALTITUDE TO (KM)	THETA (DEG)	DRANGE (KM)	RANGE (KM)	DBETA (DEG)	BETA (DEG)	PHI (DEG)	DBEND (DEG)	BENDING (DEG)	PBAR (MB)	TBAR (K)	RHOBAR (GM CM-3)
	H1 TO H2												
1	.000	1.000	.000	1.000	1.000	.000	.000	180.000	.000	.000	955.683	284.99	1.17E-03
2	1.000	2.000	.000	1.000	2.000	.000	.000	180.000	.000	.000	846.698	278.49	1.06E-03
3	2.000	3.000	.000	1.000	3.000	.000	.000	180.000	.000	.000	717.913	271.99	9.57E-04
4	3.000	4.000	.000	1.000	4.000	.000	.000	180.000	.000	.000	658.727	265.49	8.63E-04
5	4.000	5.000	.000	1.000	5.000	.000	.000	180.000	.000	.000	578.391	258.99	7.77E-04
6	5.000	6.000	.000	1.000	6.000	.000	.000	180.000	.000	.000	506.204	252.50	6.98E-04
7	6.000	7.000	.000	1.000	7.000	.000	.000	180.000	.000	.000	441.516	246.00	6.24E-04
8	7.000	8.000	.000	1.000	8.000	.000	.000	180.000	.000	.000	383.677	239.50	5.57E-04
9	8.000	9.000	.000	1.000	9.000	.000	.000	180.000	.000	.000	332.137	233.00	4.96E-04
10	9.000	10.000	.000	1.000	10.000	.000	.000	180.000	.000	.000	286.399	226.55	4.40E-04
11	10.000	11.000	.000	1.000	11.000	.000	.000	180.000	.000	.000	245.907	220.10	3.89E-04
12	11.000	12.000	.000	1.000	12.000	.000	.000	180.000	.000	.000	210.499	216.75	3.38E-04
13	12.000	13.000	.000	1.000	13.000	.000	.000	180.000	.000	.000	179.900	216.70	2.89E-04
14	13.000	14.000	.000	1.000	14.000	.000	.000	180.000	.000	.000	153.750	216.70	2.47E-04
15	14.000	15.000	.000	1.000	15.000	.000	.000	180.000	.000	.000	131.406	216.70	2.11E-04
16	15.000	16.000	.000	1.000	16.000	.000	.000	180.000	.000	.000	112.300	216.70	1.80E-04
17	16.000	17.000	.000	1.000	17.000	.000	.000	180.000	.000	.000	96.000	216.70	1.54E-04
18	17.000	18.000	.000	1.000	18.000	.000	.000	180.000	.000	.000	82.075	216.70	1.32E-04
19	18.000	19.000	.000	1.000	19.000	.000	.000	180.000	.000	.000	70.160	216.70	1.13E-04
20	19.000	20.000	.000	1.000	20.000	.000	.000	180.000	.000	.000	59.980	216.70	9.62E-05

CUMULATIVE ABSORBER AMOUNTS FOR THE PATH FROM H1 TO Z

J	Z (KM)	TBAR (K)	H2O (SCALED LOWTRAN UNITS)	CO2+ (SCALED LOWTRAN UNITS)	O3 (SCALED LOWTRAN UNITS)	HNO3 (ATM CM)	O3 UV (ATM CM)	CNTMSLF1 (MOL CM-2)	CNTMSLF2 (MOL CM-2)	CNTMFRN (MOL CM-2)
1	1.000	284.99	4.664E-01	8.586E-01	2.448E-03	.000E+00	2.528E-03	1.138E+20	3.482E+19	1.629E+22
2	2.000	278.49	7.631E-01	1.561E+00	4.775E-03	.000E+00	5.040E-03	1.700E+20	6.213E+19	2.668E+22
3	3.000	271.99	9.394E-01	2.151E+00	6.924E-03	.000E+00	7.465E-03	1.944E+20	7.842E+19	3.287E+22
4	4.000	265.49	1.037E+00	2.640E+00	8.819E-03	.000E+00	9.704E-03	2.037E+20	8.630E+19	3.631E+22
5	5.000	258.99	1.090E+00	3.043E+00	1.055E-02	.000E+00	1.185E-02	2.071E+20	8.963E+19	3.817E+22
6	6.000	252.50	1.118E+00	3.373E+00	1.218E-02	.000E+00	1.397E-02	2.082E+20	9.077E+19	3.915E+22
7	7.000	246.00	1.132E+00	3.643E+00	1.379E-02	.000E+00	1.617E-02	2.086E+20	9.115E+19	3.965E+22
8	8.000	239.50	1.139E+00	3.861E+00	1.543E-02	2.034E-35	1.852E-02	2.087E+20	9.127E+19	3.990E+22
9	9.000	233.00	1.142E+00	4.038E+00	1.732E-02	1.807E-06	2.139E-02	2.087E+20	9.130E+19	4.001E+22
10	10.000	226.55	1.144E+00	4.179E+00	1.966E-02	8.893E-06	2.515E-02	2.087E+20	9.131E+19	4.005E+22
11	11.000	220.10	1.144E+00	4.292E+00	2.268E-02	2.546E-05	3.028E-02	2.087E+20	9.131E+19	4.006E+22
12	12.000	216.75	1.144E+00	4.388E+00	2.645E-02	5.123E-05	3.705E-02	2.087E+20	9.131E+19	4.007E+22
13	13.000	216.70	1.144E+00	4.446E+00	3.048E-02	8.015E-05	4.475E-02	2.087E+20	9.131E+19	4.007E+22
14	14.000	216.70	1.144E+00	4.497E+00	3.461E-02	1.087E-04	5.315E-02	2.087E+20	9.131E+19	4.007E+22
15	15.000	216.70	1.144E+00	4.535E+00	3.892E-02	1.363E-04	6.248E-02	2.087E+20	9.131E+19	4.007E+22

TABLE C-2 (Cont).

16	16.000	216.70	1.144E+00	4.565E+00	4.347E-02	1.621E-04	7.298E-02	2.087E+20	9.131E+19	4.087E+22
17	17.000	216.70	1.144E+00	4.587E+00	4.840E-02	1.853E-04	6.512E-02	2.087E+20	9.131E+19	4.087E+22
18	18.000	216.70	1.144E+00	4.604E+00	5.375E-02	2.062E-04	9.912E-02	2.087E+20	9.131E+19	4.087E+22
19	19.000	216.70	1.144E+00	4.616E+00	5.937E-02	2.253E-04	1.148E-01	2.087E+20	9.131E+19	4.087E+22
20	20.000	216.70	1.144E+00	4.626E+00	6.512E-02	2.449E-04	1.318E-01	2.087E+20	9.131E+19	4.087E+22

I	Z (KM)	N2 CONT	MOL SCAT	AER 1	AER 2	AER 3	AER 4	CIRRUS
1	1.000	6.671E-01	9.031E-01	7.200E-01	.000E+00	.000E+00	.000E+00	.000E+00
2	2.000	1.209E+00	1.722E+00	1.051E+00	.000E+00	.000E+00	.000E+00	.000E+00
3	3.000	1.647E+00	2.462E+00	1.082E+00	1.730E-02	.000E+00	.000E+00	.000E+00
4	4.000	2.000E+00	3.131E+00	1.082E+00	4.302E-02	.000E+00	.000E+00	.000E+00
5	5.000	2.282E+00	3.732E+00	1.082E+00	5.640E-02	.000E+00	.000E+00	.000E+00
6	6.000	2.506E+00	4.272E+00	1.082E+00	6.488E-02	.000E+00	.000E+00	.000E+00
7	7.000	2.683E+00	4.755E+00	1.082E+00	7.183E-02	.000E+00	.000E+00	.000E+00
8	8.000	2.823E+00	5.186E+00	1.082E+00	7.648E-02	.000E+00	.000E+00	.000E+00
9	9.000	2.932E+00	5.570E+00	1.082E+00	7.900E-02	.000E+00	.000E+00	.000E+00
10	10.000	3.016E+00	5.910E+00	1.082E+00	7.991E-02	5.700E-04	.000E+00	.000E+00
11	11.000	3.081E+00	6.211E+00	1.082E+00	7.991E-02	1.529E-03	.000E+00	.000E+00
12	12.000	3.130E+00	6.472E+00	1.082E+00	7.991E-02	2.247E-03	.000E+00	.000E+00
13	13.000	3.166E+00	6.695E+00	1.082E+00	7.991E-02	2.823E-03	.000E+00	.000E+00
14	14.000	3.192E+00	6.886E+00	1.082E+00	7.991E-02	3.302E-03	.000E+00	.000E+00
15	15.000	3.211E+00	7.049E+00	1.082E+00	7.991E-02	3.720E-03	.000E+00	.000E+00
16	16.000	3.225E+00	7.189E+00	1.082E+00	7.991E-02	4.108E-03	.000E+00	.000E+00
17	17.000	3.235E+00	7.308E+00	1.082E+00	7.991E-02	4.512E-03	.000E+00	.000E+00
18	18.000	3.242E+00	7.410E+00	1.082E+00	7.991E-02	4.984E-03	.000E+00	.000E+00
19	19.000	3.248E+00	7.497E+00	1.082E+00	7.991E-02	5.535E-03	.000E+00	.000E+00
20	20.000	3.252E+00	7.571E+00	1.082E+00	7.991E-02	6.120E-03	.000E+00	.000E+00

SUMMARY OF THE GEOMETRY CALCULATION

```
H1      =      .000 KM
H2      =    20.000 KM

ANGLE   =      .000 DEG
RANGE   =    20.000 KM
BETA    =      .000 DEG
PHI     =   180.000 DEG
HMIN    =      .000 KM
BENDING =      .000 DEG
LEN     =         0
```

EQUIVALENT SEA LEVEL TOTAL ABSORBER AMOUNTS

H2O	CO2+	O3	HNO3	O3 UV	CNTMSLF1	CNTMSLF2	CNTMFRN
(SCALED LOWTRAN UNITS)			(ATM CM)	(ATM CM)	(MOL CM-2)	(MOL CM-2)	(MOL CM-2)
1.144E+00	4.626E+00	6.512E-02	2.449E-04	1.318E-01	2.087E+20	9.131E+19	4.087E+22

TABLE C-2 (Cont).

N2 CONT	MOL SCAT	AER 1	AER 2	AER 3	AER 4	CIRRUS	MEAN RH (PRCNT)
3.252E+00	7.571E+00	1.082E+00	7.991E-02	6.120E-03	.000E+00	.000E+00	48.25

CASE 2 : GIVEN H1, H2, ANGLE

SLANT PATH PARAMETERS IN STANDARD FORM

```
H1     =     .000 KM
H2     =  100.000 KM
ANGLE  =     .000 DEG
PHI    =  180.000 DEG
HMIN   =     .000 KM
LEN    =       0
```

CALCULATION OF THE REFRACTED PATH THROUGH THE ATMOSPHERE

H1 TO H2

I	ALTITUDE FROM (KM)	ALTITUDE TO (KM)	THETA (DEG)	DRANGE (KM)	RANGE (KM)	DBETA (DEG)	BETA (DEG)	PHI (DEG)	DBEND (DEG)	BENDING (DEG)	PBAR (MB)	TBAR (K)	RHOBAR (GM CM-3)
1	.000	1.000	.000	1.000	1.000	.000	.000	180.000	.000	.000	955.683	284.99	1.17E-03
2	1.000	2.000	.000	1.000	2.000	.000	.000	180.000	.000	.000	846.698	278.43	1.06E-03
3	2.000	3.000	.000	1.000	3.000	.000	.000	180.000	.000	.000	747.913	271.99	9.57E-04
4	3.000	4.000	.000	1.000	4.000	.000	.000	180.000	.000	.000	658.727	265.49	8.63E-04
5	4.000	5.000	.000	1.000	5.000	.000	.000	180.000	.000	.000	578.391	258.99	7.[illegible]7E-04
6	5.000	6.000	.000	1.000	6.000	.000	.000	180.000	.000	.000	506.204	252.50	6.[illegible]8E-04
7	6.000	7.000	.000	1.000	7.000	.000	.000	180.000	.000	.000	441.516	246.00	6.24E-04
8	7.000	8.000	.000	1.000	8.000	.000	.000	180.000	.000	.000	383.677	239.50	5.57E-04
9	8.000	9.000	.000	1.000	9.000	.000	.000	180.000	.000	.000	332.137	233.00	4.96E-04
10	9.000	10.000	.000	1.000	10.000	.000	.000	180.000	.000	.000	286.399	226.55	4.40E-04
11	10.000	11.000	.000	1.000	11.000	.000	.000	180.000	.000	.000	245.907	220.10	3.89E-04
12	11.000	12.000	.000	1.000	12.000	.000	.000	180.000	.000	.000	210.499	216.75	3.38E-04
13	12.000	13.000	.000	1.000	13.000	.000	.000	180.000	.000	.000	179.900	216.70	2.89E-04
14	13.000	14.000	.000	1.000	14.000	.000	.000	180.000	.000	.000	153.750	216.70	2.47E-04
15	14.000	15.000	.000	1.000	15.000	.000	.000	180.000	.000	.000	131.400	216.70	2.11E-04
16	15.000	16.000	.000	1.000	16.000	.000	.000	180.000	.000	.000	112.300	216.70	1.80E-04
17	16.000	17.000	.000	1.000	17.000	.000	.000	180.000	.000	.000	95.000	216.70	1.54E-04
18	17.000	18.000	.000	1.000	18.000	.000	.000	180.000	.000	.000	82.075	216.70	1.32E-04
19	18.000	19.000	.000	1.000	19.000	.000	.000	180.000	.000	.000	70.160	216.70	1.13E-04
20	19.000	20.000	.000	1.000	20.000	.000	.000	180.000	.000	.000	59.980	216.70	9.62E-05
21	20.000	21.000	.000	1.000	21.000	.000	.000	180.000	.000	.000	51.293	217.14	8.21E-05
22	21.000	22.000	.000	1.000	22.000	.000	.000	180.000	.000	.000	43.883	218.69	7.[illegible]0E-05
23	22.000	23.000	.000	1.000	23.000	.000	.000	180.000	.000	.000	37.572	219.09	5.96E-05
24	23.000	24.000	.000	1.000	24.000	.000	.000	180.000	.000	.000	32.197	220.09	5.09E-05
25	24.000	25.000	.000	1.000	25.000	.000	.000	180.000	.000	.000	27.607	221.09	4.34E-05
26	25.000	30.000	.000	5.000	30.000	.000	.000	180.000	.000	.000	18.754	223.73	2.79E-05
27	30.000	35.000	.000	5.000	35.000	.000	.000	180.000	.000	.000	8.860	230.82	1.28E-05
28	35.000	40.000	.000	5.000	40.000	.000	.000	180.000	.000	.000	4.322	242.52	5.95E-06
29	40.000	45.000	.000	5.000	45.000	.000	.000	180.000	.000	.000	2.187	256.43	2.86E-06
30	45.000	50.000	.000	5.000	50.000	.000	.000	180.000	.000	.000	1.146	267.09	1.45E-06
31	50.000	70.000	.000	20.000	70.000	.000	.000	180.000	.000	.000	.416	253.92	3.21E-07
32	70.000	100.000	.000	30.000	100.000	.000	.000	180.000	.000	.000	.028	217.85	1.68E-08

CUMULATIVE ABSORBER AMOUNTS FOR THE PATH FROM H1 TO Z

J	Z (KM)	TBAR (K)	H2O (SCALED LOWTRAN UNITS)	CO2+ (SCALED LOWTRAN UNITS)	O3 (SCALED LOWTRAN UNITS)	HNO3 (ATM CM)	O3 UV (ATM CM)	CNTMSLF1 (MOL CM-2)	CNTMSLF2 (MOL CM-2)	CNTMFRN (MOL CM-2)
1	1.000	284.99	4.664E-01	8.506E-01	2.440E-03	.000E+00	2.520E-03	1.138E+20	3.482E+19	1.629E+22
2	2.000	278.49	7.631E-01	1.561E+00	4.775E-03	.000E+00	5.040E-03	1.700E+20	6.213E+19	2.660E+22
3	3.000	271.99	9.394E-01	2.151E+00	6.924E-03	.000E+00	7.465E-03	1.944E+20	7.842E+19	3.287E+22
4	4.000	265.49	1.037E+00	2.640E+00	8.819E-03	.000E+00	9.704E-03	2.037E+20	8.630E+19	3.631E+22

TABLE C-2 (Cont).

TABLE C-2 (Cont).

5	5.000	253.99	1.090E+00	3.043E+00	1.055E-02	.000E+00	1.185E-02	2.071E+20	8.963E+19	3.817E+22
6	6.000	252.50	1.118E+00	3.373E+00	1.218E-02	.000E+00	1.397E-02	2.082E+20	9.077E+19	3.915E+22
7	7.000	246.00	1.132E+00	3.643E+00	1.379E-02	.000E+00	1.617E-02	2.086E+20	9.115E+19	3.965E+22
8	8.000	239.50	1.139E+[illegible]	3.861E+00	1.543E-02	2.034E-35	1.852E-02	2.087E+20	9.127E+19	3.990E+22
9	9.000	233.00	1.142E+00	4.038E+00	1.732E-02	1.807E-06	2.139E-02	2.087E+20	9.130E+19	4.001E+22
10	10.000	226.55	1.144E+00	4.179E+00	1.966E-02	8.893E-06	2.515E-02	2.087E+20	9.131E+19	4.005E+22
11	11.000	220.10	1.144E+00	4.292E+00	2.268E-02	2.546E-05	3.028E-02	2.087E+20	9.131E+19	4.006E+22
12	12.000	216.75	1.144E+00	4.380E+00	2.645E-02	5.123E-05	3.705E-02	2.087E+20	9.131E+19	4.007E+22
13	13.000	216.70	1.144E+00	4.446E+00	3.048E-02	8.015E-05	4.475E-02	2.087E+20	9.131E+19	4.007E+22
14	14.000	216.70	1.144E+00	4.497E+00	3.461E-02	1.087E-04	5.315E-02	2.087E+20	9.131E+19	4.007E+22
15	15.000	216.70	1.144E+00	4.535E+00	3.892E-02	1.363E-04	6.248E-02	2.087E+20	9.131E+19	4.007E+22
16	16.000	216.70	1.144E+00	4.565E+00	4.347E-02	1.621E-04	7.298E-02	2.087E+20	9.131E+19	4.007E+22
17	17.000	216.70	1.144E+00	4.587E+00	4.840E-02	1.853E-04	8.512E-02	2.087E+20	9.131E+19	4.007E+22
18	18.000	216.70	1.144E+00	4.604E+00	5.375E-02	2.062E-04	9.912E-02	2.087E+20	9.131E+19	4.007E+22
19	19.000	216.70	1.144E+00	4.616E+00	5.937E-02	2.253E-04	1.148E-01	2.087E+20	9.131E+19	4.007E+22
20	20.000	216.70	1.144E+00	4.626E+00	6.512E-02	2.449E-04	1.318E-01	2.087E+20	9.131E+19	4.007E+22
21	21.000	217.14	1.144E+00	4.634E+00	7.074E-02	2.661E-04	1.495E-01	2.087E+20	9.131E+19	4.007E+22
22	22.000	218.09	1.144E+00	4.639E+00	7.609E-02	2.874E-04	1.675E-01	2.087E+20	9.131E+19	4.007E+22
23	23.000	219.09	1.144E+00	4.643E+00	8.111E-02	3.089E-04	1.854E-01	2.087E+20	9.131E+19	4.007E+22
24	24.000	220.09	1.144E+00	4.647E+00	8.564E-02	3.309E-04	2.027E-01	2.087E+20	9.131E+19	4.007E+22
25	25.000	221.09	1.144E+00	4.649E+00	8.967E-02	3.472E-04	2.190E-01	2.087E+20	9.131E+19	4.007E+22
26	30.000	223.73	1.144E+00	4.655E+00	1.025E-01	3.821E-04	2.806E-01	2.087E+20	9.131E+19	4.007E+22
27	35.000	[illegible]	1.144E+00	4.656E+00	1.079E-01	3.075E-04	3.157E-01	2.087E+20	9.131E+19	4.007E+22
28	40.000	[illegible]	1.144E+00	4.657E+00	1.099E-01	3.876E-04	3.333E-01	2.087E+20	9.131E+19	4.007E+22
29	45.000	256.47	1.144E+00	4.657E+00	1.106E-01	3.876E-04	3.404E-01	2.087E+20	9.131E+19	4.007E+22
30	50.000	[illegible]	1.144E+00	4.657E+00	1.107E-01	3.876E-04	3.425E-01	2.087E+20	9.131E+19	4.007E+22
31	70.000	253.92	1.144E+00	4.657E+00	1.107E-01	3.876E-04	3.434E-01	2.087E+20	9.131E+19	4.007E+22
32	100.000	[illegible]	1.144E+00	4.657E+00	1.107E-01	3.876E-04	3.434E-01	2.087E+20	9.131E+19	4.007E+22

J	Z (KM)	N2 CONT	MOL SCAT	AER 1	AER 2	AER 3	AER 4	CIRRUS
1	1.000	6.671E-01	9.831E-01	7.700E-01	.000E+00	.000E+00	.000E+00	.000E+00
2	2.000	1.209E+00	1.722E+00	1.051E+00	.000E+00	.000E+00	.000E+00	.000E+00
3	3.000	1.647E+00	2.462E+00	1.082E+00	1.730E-02	.000E+00	.000E+00	.000E+00
4	4.000	2.000E+00	3.131E+00	1.082E+00	4.302E-02	.000E+00	.000E+00	.000E+00
5	5.000	2.282E+00	3.732E+00	1.082E+00	5.640E-02	.000E+00	.000E+00	.000E+00
6	6.000	2.506E+00	4.272E+00	1.082E+00	6.488E-02	.000E+00	.000E+00	.000E+00
7	7.000	2.683E+00	4.755E+00	1.082E+00	7.183E-02	.000E+00	.000E+00	.000E+00
8	8.000	2.823E+00	5.186E+00	1.082E+00	7.648E-02	.000E+00	.000E+00	.000E+00
9	9.000	2.932E+00	5.570E+00	1.082E+00	7.900E-02	.000E+00	.000E+00	.000E+00
10	10.000	3.016E+00	5.910E+00	1.082E+00	7.991E-02	5.700E-04	.000E+00	.000E+00
11	11.000	3.081E+00	6.211E+00	1.082E+00	7.991E-02	1.529E-03	.000E+00	.000E+00
12	12.000	3.130E+00	6.472E+00	1.082E+00	7.991E-02	2.247E-03	.000E+00	.000E+00
13	13.000	3.166E+00	6.695E+00	1.082E+00	7.991E-02	2.823E-03	.000E+00	.000E+00
14	14.000	3.192E+00	6.886E+00	1.082E+00	7.991E-02	3.302E-03	.000E+00	.000E+00
15	15.000	3.211E+00	7.049E+00	1.082E+00	7.991E-02	3.720E-03	.000E+00	.000E+00
16	16.000	3.225E+00	7.189E+00	1.082E+00	7.991E-02	4.108E-03	.000E+00	.000E+00
17	17.000	3.235E+00	7.308E+00	1.082E+00	7.991E-02	4.512E-03	.000E+00	.000E+00

TABLE C-2 (Cont).

18	18.000	3.242E+00	7.410E+00	1.082E+00	7.991E-02	4.984E-03	.000E+00	.000E+00
19	19.000	3.248E+00	7.497E+00	1.082E+00	7.991E-02	5.535E-03	.000E+00	.000E+00
20	20.000	3.252E+00	7.571E+00	1.082E+00	7.991E-02	6.120E-03	.000E+00	.000E+00
21	21.000	3.254E+00	7.635E+00	1.082E+00	7.991E-02	6.664E-03	.000E+00	.000E+00
22	22.000	3.257E+00	7.689E+00	1.082E+00	7.991E-02	7.124E-03	.000E+00	.000E+00
23	23.000	3.258E+00	7.735E+00	1.082E+00	7.991E-02	7.481E-03	.000E+00	.000E+00
24	24.000	3.259E+00	7.775E+00	1.0825+00	7.991E-02	7.726E-03	.000E+00	.000E+00
25	25.000	3.260E+00	7.808E+00	1.082E+00	7.991E-02	7.808E-03	.000E+00	.000E+00
26	30.000	3.262E+00	7.916E+00	1.082E+00	7.991E-02	8.245E-03	.000E+00	.000E+00
27	35.000	3.262E+00	7.966E+00	1.082E+00	7.991E-02	8.328E-03	4.100E-05	.000E+00
28	40.000	3.262E+00	7.989E+00	1.082E+00	7.991E-02	8.328E-03	9.948E-05	.000E+00
29	45.000	3.262E+00	8.000E+00	1.082E+00	7.991E-02	8.328E-03	1.283E-04	.000E+00
30	50.000	3.262E+00	8.005E+00	1.082E+00	7.991E-02	8.328E-03	1.431E-04	.000E+00
31	70.000	3.262E+00	8.011E+00	1.082E+00	7.991E-02	8.328E-03	1.582E-04	.000E+00
32	100.000	3.262E+00	8.012E+00	1.092E+00	7.991E-02	8.328E-03	1.591E-04	.000E+00

SUMMARY OF THE GEOMETRY CALCULATION

H1	=	.000 KM
H2	=	100.000 KM
ANGLE	=	.000 DEG
RANGE	=	100.000 KM
BETA	=	.000 DEG
PHI	=	180.000 DEG
HMIN	=	.000 KM
BENDING	=	.000 DEG
LEN	=	0

EQUIVALENT SEA LEVEL TOTAL ABSORBER AMOUNTS

H2O	CO2+	O3	HNO3	O3 UV	CNTMSLF1	CNTMSLF2	CNTMFRN
(SCALED LOWTRAN UNITS)			(ATM CM)	(ATM CM)	(MOL CM-2)	(MOL CM-2)	(MOL CM-2)
1.144E+00	4.657E+00	1.107E-01	3.876E-04	3.434E-01	2.087E+20	9.131E+19	4.007E+22

N2 CONT	MOL SCAT	AER 1	AER 2	AER 3	AER 4	CIRRUS	MEAN RH (PRCNT)
3.262E+00	8.012E+00	1.082E+00	7.991E-02	8.328E-03	1.591E-04	.000E+00	48.25

TABLE C-2 (Cont).

RADIANCE(WATTS/CM2-STER-XXX)

FREQ (CM-1)	WAVLEN (MICRN)	ATMOS RADIANCE (CM-1)	(MICRN)	INTEGRAL (CM-1)	TOTAL TRANS
850.	11.765	2.23E-06	1.61E-04	5.57E-06	.7544
855.	11.696	2.12E-06	1.55E-04	1.62E-05	.7627
860.	11.628	1.98E-06	1.47E-04	2.61E-05	.7727
865.	11.561	1.81E-06	1.35E-04	3.52E-05	.7866
870.	11.494	1.67E-06	1.27E-04	4.35E-05	.7970
875.	11.429	1.66E-06	1.27E-04	5.18E-05	.7969
880.	11.364	1.66E-06	1.28E-04	6.01E-05	.7949
885.	11.299	1.62E-06	1.27E-04	6.82E-05	.7966
890.	11.236	1.56E-06	1.24E-04	7.60E-05	.8010
695.	11.173	1.51E-06	1.21E-04	8.35E-05	.8043
900.	11.111	1.45E-06	1.17E-04	9.08E-05	.8084
905.	11.050	1.46E-06	1.20E-04	9.81E-05	.8053
910.	10.989	1.45E-06	1.20E-04	1.05E-04	.8043
915.	10.929	1.44E-06	1.21E-04	1.13E-04	.8028
920.	10.870	1.41E-06	1.19E-04	1.20E-04	.8035
925.	10.811	1.27E-06	1.09E-04	1.26E-04	.8133
930.	10.753	1.27E-06	1.10E-04	1.32E-04	.8116
935.	10.695	1.28E-06	1.12E-04	1.39E-04	.8079
940.	10.638	1.31E-06	1.15E-04	1.45E-04	.8024
945.	10.582	1.36E-06	1.21E-04	1.52E-04	.7932
950.	10.526	1.39E-06	1.25E-04	1.55E-04	.7857

INTEGRATED ABSORPTION FROM 850 TO 950 CM-1 = 20.32 CM-1

AVERAGE TRANSMITTANCE = .7968

INTEGRATED RADIANCE = 1.555E-04 WATTS CM-2 STER-1
MINIMUM RADIANCE = 1.268E-06 WATTS CM-2 STER-1 (CM-1)-1 AT 930.0 CM-1
MAXIMUM RADIANCE = 2.229E-06 WATTS CM-2 STER-1 (CM-1)-1 AT 850.0 CM-1
BOUNDARY TEMPERATURE = .00 K
BOUNDARY EMISSIVITY = 1.000

CARD 5 ***** 0

17.46.51.UCLP, AA, LP2 , 0.960KLNS.

TABLE C-3

LOWTRAN OUTPUT FOR CASE 2

```
                    ***** LOWTRAN 6 *****

CARD 1  *****    6    2    1    0    0    0    0    0       .000       .000     1

CARD 2  *****    2    0    0    0    0    0       .000       .000       .000       .000

CARD 3  *****    20.000      .000   180.000      .000       .000       .000     0

CARD 4  *****   850.000   950.000      5.000

PROGRAM WILL COMPUTE RADIANCE

CALCULATIONS WILL    DONE USING MULTIPLE SCATTERING

ATMOSPHERIC MODEL
        TEMPERATURE =    6      1962 U S STANDARD

        WATER VAPOR =    6      1962 U S STANDARD
        OZONE       =    6      1962 U S STANDARD

AEROSOL MODEL
        REGIME                  AEROSOL TYPE             PROFILE                  SEASON

        BOUNDARY LAYER (0-2 KM) RURAL                     5.0 KM VIS AT SEA LEVEL
        TROPOSPHERE  (2-10KM)   TROPOSPHERIC             TROPOSPHERIC             SPRING-SUMMER
        STRATOSPHERE (10-30KM)  BACKGROUND STRATO        BACKGROUND STRATO        SPRING-SUMMER

        UPPER ATMOS (30-100KM)  METEORIC DUST            NORMAL

SLANT PATH, H1 TO H2
        H1     =     20.000 KM
        H2     =       .000 KM
        ANGLE  =    180.000 DEG
        RANGE  =       .000 KM
        BETA   =       .000 DEG
        LEN    =      0

FREQUENCY RANGE
         V1 =         850.0 CM-1  (      11.76 MICROMETERS)
         V2 =         950.0 CM-1  (      10.53 MICROMETERS)
         DV =           5.0 CM-1
```

TABLE C-3 (Cont).

ATMOSPHERIC PROFILES

I	Z (KM)	P (MB)	T (K)	H2O	CO2+ (SCALED	O3 LOWTRAN	N2 UNITS)	CNTMSLF (MOL/CM2 KM)	MOL SCAT (-)	N-1 (-)	O3 (UV) (ATM CM/KM)
1	.00	1013.000	288.2	5.758E-01	9.285E-01	2.493E-03	7.378E-01	1.569E+20	9.475E-01	2.722E-04	2.520E-03
2	1.00	898.800	281.7	3.719E-01	7.771E-01	2.387E-03	6.010E-01	7.951E+19	8.601E-01	2.471E-04	2.520E-03
3	2.00	795.000	275.2	2.323E-01	6.474E-01	2.294E-03	4.870E-01	3.791E+19	7.788E-01	2.238E-04	2.520E-03
4	3.00	701.200	268.7	1.302E-01	5.371E-01	2.020E-03	3.927E-01	1.460E+19	7.035E-01	2.022E-04	2.333E-03
5	4.00	616.600	262.2	7.166E-02	4.435E-01	1.774E-03	3.150E-01	5.454E+18	6.340E-01	1.823E-04	2.147E-03
6	5.00	540.500	255.7	3.745E-02	3.646E-01	1.692E-03	2.513E-01	1.846E+18	5.698E-01	1.638E-04	2.147E-03
7	6.00	472.200	249.2	1.992E-02	2.982E-01	1.576E-03	1.994E-01	5.508E+17	5.108E-01	1.469E-04	2.100E-03
8	7.00	411.100	242.7	9.834E-03	2.427E-01	1.632E-03	1.572E-01	1.388E+17	4.566E-01	1.313E-04	2.287E-03
9	8.00	356.500	236.2	5.004E-03	1.963E-01	1.645E-03	1.232E-01	6.490E+16	4.069E-01	1.170E-04	2.427E-03
10	9.00	308.000	229.7	1.703E-03	1.579E-01	2.130E-03	9.586E-02	9.537E+15	3.615E-01	1.040E-04	3.313E-03
11	10.00	265.000	223.3	5.894E-04	1.262E-01	2.557E-03	7.403E-02	1.460E+15	3.199E-01	9.201E-05	4.200E-03
12	11.00	227.000	216.8	2.367E-04	1.002E-01	3.493E-03	5.678E-02	3.031E+14	2.823E-01	8.118E-05	5.067E-03
13	12.00	194.000	216.7	9.275E-05	7.619E-02	4.037E-03	4.150E-02	6.170E+13	2.413E-01	6.941E-05	7.467E-03
14	13.00	165.800	216.7	3.917E-05	5.788E-02	4.028E-03	3.031E-02	1.460E+13	2.063E-01	5.932E-05	7.933E-03
15	14.00	141.700	216.7	1.587E-05	4.397E-02	4.229E-03	2.214E-02	3.180E+12	1.763E-01	5.070E-05	8.867E-03
16	15.00	121.100	216.7	1.181E-05	3.340E-02	4.388E-03	1.617E-02	2.337E+12	1.507E-01	4.333E-05	9.800E-03
17	16.00	103.500	216.7	8.687E-06	2.537E-02	4.710E-03	1.181E-02	1.677E+12	1.288E-01	3.703E-05	1.120E-02
18	17.00	88.500	216.7	6.432E-06	1.929E-02	5.161E-03	8.637E-03	1.219E+12	1.101E-01	3.166E-05	1.307E-02
19	18.00	75.650	216.7	4.726E-06	1.466E-02	5.540E-03	6.311E-03	8.726E+11	9.411E-02	2.707E-05	1.493E-02
20	19.00	64.670	216.7	4.104E-06	1.114E-02	5.691E-03	4.612E-03	8.726E+11	8.045E-02	2.314E-05	1.633E-02
21	20.00	55.290	216.7	3.564E-06	8.470E-03	5.803E-03	3.371E-03	8.726E+11	6.878E-02	1.978E-05	1.773E-02
22	21.00	47.290	217.6	3.371E-06	6.406E-03	5.447E-03	2.451E-03	1.038E+12	5.859E-02	1.685E-05	1.773E-02
23	22.00	40.470	218.6	3.168E-06	4.847E-03	5.248E-03	1.783E-03	1.219E+12	4.991E-02	1.435E-05	1.820E-02
24	23.00	34.670	219.6	3.015E-06	3.675E-03	4.802E-03	1.299E-03	1.464E+12	4.256E-02	1.224E-05	1.773E-02
25	24.00	29.720	220.6	2.803E-06	2.789E-03	4.274E-03	9.483E-04	1.677E+12	3.632E-02	1.044E-05	1.689E-02
26	25.00	25.490	221.6	2.636E-06	2.119E-03	3.792E-03	6.929E-04	1.963E+12	3.101E-02	8.918E-06	1.587E-02
27	30.00	11.970	226.5	7.612E-07	5.476E-04	1.642E-03	1.479E-04	6.508E+11	1.425E-02	4.097E-06	9.333E-03
28	35.00	5.746	236.5	1.624E-07	1.429E-04	6.674E-04	3.193E-05	1.154E+11	6.550E-03	1.884E-06	5.133E-03
29	40.00	2.871	250.4	3.549E-08	3.922E-05	2.227E-04	7.318E-06	2.023E+10	3.091E-03	8.889E-07	2.287E-03
30	45.00	1.491	264.2	9.176E-09	1.157E-05	5.881E-05	1.821E-06	4.615E+09	1.521E-03	4.375E-07	7.933E-04
31	50.00	.798	270.7	1.939E-09	3.747E-06	1.072E-05	5.027E-07	6.490E+08	7.945E-04	2.285E-07	1.867E-04
32	70.00	.055	219.7	2.406E-12	4.660E-08	8.259E-08	3.291E-09	1.014E+05	6.773E-05	1.948E-08	4.013E-06
33	100.00	.000	210.0	1.502E-16	5.420E-12	5.180E-12	1.046E-13	4.507E+00	3.861E-07	1.111E-10	2.007E-09

ATMOSPHERIC PROFILES

I	Z (KM)	P (MB)	T (K)	CNTMFRN MOL/CM2 KM	HNO3 ATM CM/KM	AEROSOL 1 (-)	AEROSOL 2 (-)	AEROSOL 3 (-)	AEROSOL 4 (-)	AER1*RH (-)	CIRRUS (-)	RH (PERCNT)
1	.00	1013.000	288.2	2.010E+22	.000E+00	7.700E-01	.000E+00	.000E+00	.000E+00	3.533E+01	.000E+00	4.589E+01
2	1.00	898.800	281.7	1.301E+22	.000E+00	7.700E-01	.000E+00	.000E+00	.000E+00	3.777E+01	.000E+00	4.906E+01
3	2.00	795.000	275.2	5.143E+21	.000E+00	6.210E-02	.000E+00	.000E+00	.000E+00	3.230E+00	.000E+00	5.201E+01
4	3.00	701.200	269.7	4.573E+21	.000E+00	.000E+00	3.460E-02	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
5	4.00	516.600	262.2	2.521E+21	.000E+00	.000E+00	1.850E-02	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
6	5.00	540.500	255.7	1.319E+21	.000E+00	.000E+00	9.310E-03	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
7	6.00	472.200	249.2	7.025E+20	.000E+00	.000E+00	7.710E-03	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
8	7.00	411.100	242.7	3.472E+20	.000E+00	.000E+00	6.230E-03	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
9	8.00	356.500	236.2	1.768E+20	4.069E-35	.000E+00	3.370E-03	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
10	9.00	308.000	229.7	6.023E+19	3.615E-06	.000E+00	1.820E-03	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
11	10.00	265.000	223.3	2.086E+19	1.056E-05	.000E+00	.000E+00	1.140E-03	.000E+00	.000E+00	.000E+00	.000E+00
12	11.00	227.000	216.8	8.384E+18	2.258E-05	.000E+00	.000E+00	7.990E-04	.000E+00	.000E+00	.000E+00	.000E+00
13	12.00	194.000	216.7	3.235E+18	2.896E-05	.000E+00	.000E+00	6.410E-04	.000E+00	.000E+00	.000E+00	.000E+00
14	13.00	165.800	216.7	1.345E+18	2.888E-05	.000E+00	.000E+00	5.170E-04	.000E+00	.000E+00	.000E+00	.000E+00
15	14.00	141.700	216.7	5.364E+17	2.820E-05	.000E+00	.000E+00	4.420E-04	.000E+00	.000E+00	.000E+00	.000E+00
16	15.00	121.100	216.7	3.929E+17	2.712E-05	.000E+00	.000E+00	3.950E-04	.000E+00	.000E+00	.000E+00	.000E+00
17	16.00	103.500	216.7	2.845E+17	2.446E-05	.000E+00	.000E+00	3.820E-04	.000E+00	.000E+00	.000E+00	.000E+00
18	17.00	88.500	216.7	2.074E+17	2.282E-05	.000E+00	.000E+00	4.250E-04	.000E+00	.000E+00	.000E+00	.000E+00
19	18.00	75.650	216.7	1.500E+17	1.976E-05	.000E+00	.000E+00	5.200E-04	.000E+00	.000E+00	.000E+00	.000E+00
20	19.00	64.670	216.7	1.282E+17	1.850E-05	.000E+00	.000E+00	5.810E-04	.000E+00	.000E+00	.000E+00	.000E+00
21	20.00	55.290	216.7	1.096E+17	2.063E-05	.000E+00	.000E+00	5.890E-04	.000E+00	.000E+00	.000E+00	.000E+00
22	21.00	47.290	217.6	1.019E+17	2.168E-05	.000E+00	.000E+00	5.020E-04	.000E+00	.000E+00	.000E+00	.000E+00
23	22.00	40.470	218.6	9.401E+16	2.096E-05	.000E+00	.000E+00	4.200E-04	.000E+00	.000E+00	.000E+00	.000E+00
24	23.00	34.670	219.6	8.788E+16	2.213E-05	.000E+00	.000E+00	3.000E-04	.000E+00	.000E+00	.000E+00	.000E+00
25	24.00	29.720	220.6	8.025E+16	2.179E-05	.000E+00	.000E+00	1.980E-04	.000E+00	.000E+00	.000E+00	.000E+00
26	25.00	25.490	221.6	7.414E+16	1.178E-05	.000E+00	.000E+00	1.310E-04	.000E+00	.000E+00	.000E+00	.000E+00
27	30.00	11.970	226.5	1.961E+16	3.704E-06	.000E+00	.000E+00	3.320E-05	.000E+00	.000E+00	.000E+00	.000E+00
28	35.00	5.746	236.5	3.796E+15	1.441E-07	.000E+00	.000E+00	.000E+00	1.640E-05	.000E+00	.000E+00	.000E+00
29	40.00	2.871	250.4	7.502E+14	3.091E-37	.000E+00	.000E+00	.000E+00	7.990E-06	.000E+00	.000E+00	.000E+00
30	45.00	1.491	264.2	1.764E+14	.000E+00	.000E+00	.000E+00	.000E+00	4.010E-06	.000E+00	.000E+00	.000E+00
31	50.00	.798	270.7	3.454E+13	.000E+00	.000E+00	.000E+00	.000E+00	2.100E-06	.000E+00	.000E+00	.000E+00
32	70.00	.055	219.7	3.680E+10	.000E+00	.000E+00	.000E+00	.000E+00	1.600E-07	.000E+00	.000E+00	.000E+00
33	100.00	.000	210.0	1.399E+06	.000E+00	.000E+00	.000E+00	.000E+00	9.310E-10	.000E+00	.000E+00	.000E+00

CASE 2A: GIVEN H1, H2, ANGLE

EITHER A SHORT PATH (LEN=0) OR A LONG PATH THROUGH A TANGENT HEIGHT (LEN=1) IS POSSIBLE: LEN = 0

SLANT PATH PARAMETERS IN STANDARD FORM

TABLE C-3 (Cont).

```
H1      =      20.000 KM
H2      =        .000 KM

ANGLE   =     180.000 DEG
PHI     =        .000 DEG
HMIN    =        .000 KM
LEN     =           0
```

TABLE C-3 (Cont).

CALCULATION OF THE REFRACTED PATH THROUGH THE ATMOSPHERE

I	ALTITUDE FROM (KM)	ALTITUDE TO (KM)	THETA (DEG)	DRANGE (KM)	RANGE (KM)	DBETA (DEG)	BETA (DEG)	PHI (DEG)	DBEND (DEG)	BENDING (DEG)	PBAR (MB)	TBAR (K)	RHOBAR (GM CM-3)
	H2 TO H1												
1	.000	1.000	.000	1.000	1.000	.000	.000	180.000	.000	.000	955.683	284.99	1.17E-03
2	1.000	2.000	.000	1.000	2.000	.000	.000	180.000	.000	.000	845.698	278.49	1.06E-03
3	2.000	3.000	.000	1.000	3.000	.000	.000	180.000	.000	.000	747.913	271.99	9.57E-04
4	3.000	4.000	.000	1.000	4.000	.000	.000	180.000	.000	.000	658.727	265.49	8.63E-04
5	4.000	5.000	.000	1.000	5.000	.000	.000	180.000	.000	.000	578.391	258.99	7.77E-04
6	5.000	6.000	.000	1.000	6.000	.000	.000	180.000	.000	.000	506.204	252.50	6.98E-04
7	6.000	7.000	.000	1.000	7.000	.000	.000	180.000	.000	.000	441.516	246.00	6.24E-04
8	7.000	8.000	.000	1.000	8.000	.000	.000	180.000	.000	.000	363.677	239.50	[illegible]
9	8.000	9.000	.000	1.000	9.000	.000	.000	180.000	.000	.000	332.137	233.00	[illegible]
10	9.000	10.000	.000	1.000	10.000	.000	.000	180.000	.000	.000	286.399	226.55	4.40E-04
11	10.000	11.000	.000	1.000	11.000	.000	.000	180.000	.000	.000	245.907	220.12	3.89E-04
12	11.000	12.000	.000	1.000	12.000	.000	.000	180.000	.000	.000	210.499	216.75	3.38E-04
13	12.000	13.000	.000	1.000	13.000	.000	.000	180.000	.000	.000	179.900	216.70	2.89E-04
14	13.000	14.000	.000	1.000	14.000	.000	.000	180.000	.000	.000	153.750	216.70	2.47E-04
15	14.000	15.000	.000	1.000	15.000	.000	.000	180.000	.000	.000	131.400	216.70	2.11E-04
16	15.000	16.000	.000	1.000	16.000	.000	.000	180.000	.000	.000	112.300	216.70	1.80E-04
17	16.000	17.000	.000	1.000	17.000	.000	.000	180.000	.000	.000	96.000	216.72	1.54E-04
18	17.000	18.000	.000	1.000	18.000	.000	.000	180.000	.000	.000	82.075	216.70	1.32E-04
19	18.000	19.000	.000	1.000	19.000	.000	.000	180.000	.000	.000	70.160	216.70	1.13E-04
20	19.000	20.000	.000	1.000	20.000	.000	.000	180.000	.000	.000	59.980	216.70	9.62E-05

CUMULATIVE ABSORBER AMOUNTS FOR THE PATH FROM H1 TO Z

J	Z (KM)	TBAR (K)	H2O (SCALED LOWTRAN UNITS)	CO2+ (SCALED LOWTRAN UNITS)	O3 (SCALED LOWTRAN UNITS)	HNO3 (ATM CM)	O3 UV (ATM CM)	CNTMSLF1 (MOL CM-2)	CNTMSLF2 (MOL CM-2)	CNTMFRN (MOL CM-2)
1	19.000	216.70	3.828E-06	9.745E-03	5.747E-03	1.957E-05	1.703E-02	8.726E+11	8.726E+11	1.187E+17
2	18.000	216.70	8.235E-06	2.257E-02	1.136E-02	3.870E-05	3.267E-02	1.745E+12	1.745E+12	2.575E+17
3	17.000	216.70	1.377E-05	3.944E-02	1.671E-02	5.957E-05	4.667E-02	2.781E+12	2.781E+12	4.347E+17
4	16.000	216.70	2.127E-05	6.163E-02	2.165E-02	8.270E-05	5.880E-02	4.217E+12	4.217E+12	6.706E+17
5	15.000	216.70	3.144E-05	9.083E-02	2.620E-02	1.086E-04	6.930E-02	6.206E+12	6.206E+12	1.014E+18
6	14.000	216.70	4.518E-05	1.293E-01	3.051E-02	1.362E-04	7.863E-02	8.942E+12	8.942E+12	1.475E+18
7	13.000	216.70	7.097E-05	1.799E-01	3.463E-02	1.647E-04	8.703E-02	1.644E+13	1.644E+13	2.355E+18
8	12.000	216.70	1.331E-04	2.465E-01	3.867E-02	1.937E-04	9.473E-02	4.912E+13	4.912E+13	4.508E+18
9	11.000	216.75	2.868E-04	3.342E-01	4.243E-02	2.194E-04	1.015E-01	2.008E+14	2.008E+14	9.915E+18
10	10.000	220.10	6.734E-04	4.469E-01	4.546E-02	2.360E-04	1.066E-01	9.367E+14	9.367E+14	2.360E+19
11	9.000	226.55	1.723E-03	5.883E-01	4.780E-02	2.431E-04	1.104E-01	5.241E+15	5.241E+15	6.073E+19
12	8.000	233.00	4.785E-03	7.647E-01	4.969E-02	2.449E-04	1.133E-01	3.411E+16	3.411E+16	1.690E+20
13	7.000	239.50	1.193E-02	9.834E-01	5.133E-02	2.449E-04	1.156E-01	1.537E+17	1.537E+17	4.215E+20
14	6.000	246.00	2.622E-02	1.253E+00	5.293E-02	2.449E-04	1.178E-01	5.348E+17	5.348E+17	9.256E+20
15	5.000	252.50	5.399E-02	1.583E+00	5.456E-02	2.449E-04	1.199E-01	1.681E+18	1.681E+18	1.904E+21

TABLE C-3 (Cont).

16	4.000	258.99	1.067E-01	1.986E+00	5.630E-02	2.449E-04	1.221E-01	5.012E+18	5.012E+18	3.760E+21
17	3.000	265.49	2.047E-01	2.475E+00	5.819E-02	2.449E-04	1.243E-01	1.430E+19	1.288E+19	7.205E+21
18	2.000	271.99	3.811E-01	3.065E+00	6.034E-02	2.449E-04	1.267E-01	3.873E+19	2.918E+19	1.339E+22
19	1.000	278.49	6.778E-01	3.776E+00	6.268E-02	2.449E-04	1.293E-01	9.489E+19	5.649E+19	2.378E+22
20	.000	284.99	1.144E+00	4.626E+00	6.512E-02	2.449E-04	1.318E-01	2.087E+20	9.131E+19	4.007E+22

J	Z (KM)	N2 CONT	MOL SCAT	AER 1	AER 2	AER 3	AER 4	CIRRUS
1	19.000	3.959E-03	7.446E-02	.000E+00	.000E+00	5.850E-04	.000E+00	.000E+00
2	18.000	9.376E-03	1.616E-01	.000E+00	.000E+00	1.136E-03	.000E+00	.000E+00
3	17.000	1.679E-02	2.635E-01	.000E+00	.000E+00	1.608E-03	.000E+00	.000E+00
4	16.000	2.693E-02	3.826E-01	.000E+00	.000E+00	2.012E-03	.000E+00	.000E+00
5	15.000	4.081E-02	5.221E-01	.000E+00	.000E+00	2.400E-03	.000E+00	.000E+00
6	14.000	5.981E-02	6.852E-01	.000E+00	.000E+00	2.818E-03	.000E+00	.000E+00
7	13.000	8.582E-02	8.761E-01	.000E+00	.000E+00	3.297E-03	.000E+00	.000E+00
8	12.000	1.214E-01	1.099E+00	.000E+00	.000E+00	3.873E-03	.000E+00	.000E+00
9	11.000	1.702E-01	1.361E+00	.000E+00	.000E+00	4.590E-03	.000E+00	.000E+00
10	10.000	2.352E-01	1.661E+00	.000E+00	.000E+00	5.550E-03	.000E+00	.000E+00
11	9.000	3.197E-01	2.002E+00	.000E+00	9.100E-04	6.120E-03	.000E+00	.000E+00
12	8.000	4.286E-01	2.385E+00	.000E+00	3.426E-03	6.120E-03	.000E+00	.000E+00
13	7.000	5.681E-01	2.817E+00	.000E+00	8.080E-03	6.120E-03	.000E+00	.000E+00
14	6.000	7.456E-01	3.300E+00	.000E+00	1.502E-02	6.120E-03	.000E+00	.000E+00
15	5.000	9.700E-01	3.840E+00	.000E+00	2.351E-02	6.120E-03	.000E+00	.000E+00
16	4.000	1.252E+00	4.441E+00	.000E+00	3.689E-02	6.120E-03	.000E+00	.000E+00
17	3.000	1.604E+00	5.109E+00	.000E+00	6.261E-02	6.120E-03	.000E+00	.000E+00
18	2.000	2.042E+00	5.850E+00	3.105E-02	7.991E-02	6.120E-03	.000E+00	.000E+00
19	1.000	2.585E+00	6.668E+00	3.122E-01	7.991E-02	6.120E-03	.000E+00	.000E+00
20	.000	3.252E+00	7.571E+00	1.082E+00	7.991E-02	6.120E-03	.000E+00	.000E+00

SUMMARY OF THE GEOMETRY CALCULATION

```
H1      =    20.000 KM
H2      =      .000 KM
ANGLE   =   180.000 DEG
RANGE   =    20.000 KM
BETA    =      .000 DEG
PHI     =      .000 DEG
HMIN    =      .000 KM
BENDING =      .000 DEG
LEN     =         0
```

EQUIVALENT SEA LEVEL TOTAL ABSORBER AMOUNTS

H2O	CO2+	O3	HNO3	O3 UV	CNTMSLF1	CNTMSLF2	CNTMFRN
(SCALED LOWTRAN UNITS)			(ATM CM)	(ATM CM)	(MOL CM-2)	(MOL CM-2)	(MOL CM-2)
1.144E+00	4.626E+00	6.512E-02	2.449E-04	1.318E-01	2.087E+20	9.131E+19	4.007E+22

TABLE C-3 (Cont).

N2 CONT	MOL SCAT	AER 1	AER 2	AER 3	AER 4	CIRRUS	MEAN RH (PRCNT)
3.252E+00	7.571E+00	1.082E+00	7.991E-02	6.120E-03	.000E+00	.000E+00	48.25

CASE 2D: GIVEN H1, H2, BETA:

ITERATE AROUND ANGLE UNTIL BETA CONVERGES

ITER	ANGLE (DEG)	BETA (DEG)	DBETA (DEG)	RANGE (KM)	HMIN (KM)	PHI (DEG)	BENDING (DEG)
1	.0000	.0000	.0000	100.000	.000	180.0000	.0000
2	.0000	.0000	.0000	100.000	.000	180.0000	.0000

SLANT PATH PARAMETERS IN STANDARD FORM

H1	=	100.000 KM
H2	=	.000 KM
ANGLE	=	180.000 DEG
PHI	=	.000 DEG
HMIN	=	.000 KM
LEN	=	0

TABLE C-3 (Cont).

CALCULATION OF THE REFRACTED PATH THROUGH THE ATMOSPHERE

I	ALTITUDE FROM (KM)	ALTITUDE TO (KM)	THETA (DEG)	DRANGE (KM)	RANGE (KM)	DBETA (DEG)	BETA (DEG)	PHI (DEG)	DBEND (DEG)	BENDING (DEG)	PBAR (MB)	TBAR (K)	RHOBAR (GM CM-3)
	H2 TO H1												
1	.000	1.000	.000	1.000	1.000	.000	.000	180.000	.000	.000	955.683	284.99	1.17E-03
2	1.000	2.000	.000	1.000	2.000	.000	.000	180.000	.000	.000	846.698	278.49	1.06E-03
3	2.000	3.000	.000	1.000	3.000	.000	.000	180.000	.000	.000	747.913	271.99	9.57E-04
4	3.000	4.000	.000	1.000	4.000	.000	.000	180.000	.000	.000	658.727	265.49	8.63E-04
5	4.000	5.000	.000	1.000	5.000	.000	.000	180.000	.000	.000	578.391	258.99	7.77E-04
6	5.000	6.000	.000	1.000	6.000	.000	.000	180.000	.000	.000	506.204	252.50	6.98E-04
7	6.000	7.000	.000	1.000	7.000	.000	.000	180.000	.000	.000	441.516	246.00	6.24E-04
8	7.000	8.000	.000	1.000	8.000	.000	.000	180.000	.000	.000	383.677	239.50	5.57E-04
9	8.000	9.000	.000	1.000	9.000	.000	.000	180.000	.000	.000	332.137	233.00	4.96E-04
10	9.000	10.000	.000	1.000	10.000	.000	.000	180.000	.000	.000	286.399	226.55	4.40E-04
11	10.000	11.000	.000	1.000	11.000	.000	.000	180.000	.000	.000	245.907	220.10	3.89E-04
12	11.000	12.000	.000	1.000	12.000	.000	.000	180.000	.000	.000	210.499	216.75	3.38E-04
13	12.000	13.000	.000	1.000	13.000	.000	.000	180.000	.000	.000	179.900	216.70	2.89E-04
14	13.000	14.000	.000	1.000	14.000	.000	.000	180.000	.000	.000	153.750	216.70	2.47E-04
15	14.000	15.000	.000	1.000	15.000	.000	.000	180.000	.000	.000	131.400	216.70	2.11E-04
16	15.000	16.000	.000	1.000	16.000	.000	.000	180.000	.000	.000	112.300	216.70	1.80E-04
17	16.000	17.000	.000	1.000	17.000	.000	.000	180.000	.000	.000	96.000	216.70	1.54E-04
18	17.000	18.000	.000	1.000	18.000	.000	.000	180.000	.000	.000	82.075	216.70	1.32E-04
19	18.000	19.000	.000	1.000	19.000	.000	.000	180.000	.000	.000	70.160	216.70	1.13E-04
20	19.000	20.000	.000	1.000	20.000	.000	.000	180.000	.000	.000	59.980	216.70	9.62E-05
21	20.000	21.000	.000	1.000	21.000	.000	.000	180.000	.000	.000	51.293	217.14	8.21E-05
22	21.000	22.000	.000	1.000	22.000	.000	.000	180.000	.000	.000	43.683	218.03	7.02E-05
23	22.000	23.000	.000	1.000	23.000	.000	.000	180.000	.000	.000	37.572	219.09	5.96E-05
24	23.000	24.000	.000	1.000	24.000	.000	.000	180.000	.000	.000	32.197	220.03	5.09E-05
25	24.000	25.000	.000	1.000	25.000	.000	.000	180.000	.000	.000	27.607	221.09	4.34E-05
26	25.000	30.000	.000	5.000	30.000	.000	.000	180.000	.000	.000	18.754	223.73	2.19E-05
27	30.000	35.000	.000	5.000	35.000	.000	.000	180.000	.000	.000	8.880	230.82	1.28E-05
28	35.000	40.000	.000	5.000	40.000	.000	.000	180.000	.000	.000	4.322	242.52	5.95E-06
29	40.000	45.000	.000	5.000	45.000	.000	.000	180.000	.000	.000	2.187	256.43	2.86E-06
30	45.000	50.000	.000	5.000	50.000	.000	.000	180.000	.000	.000	1.146	267.09	1.45E-06
31	50.000	70.000	.000	20.000	70.000	.000	.000	180.000	.000	.000	.416	253.92	3.81E-07
32	70.000	100.000	.000	30.000	100.000	.000	.000	180.000	.000	.000	.028	217.85	1.68E-08

CUMULATIVE ABSORBER AMOUNTS FOR THE PATH FROM H1 TO Z

J	Z (KM)	TBAR (K)	H2O (SCALED LOWTRAN UNITS)	CO2+ (SCALED LOWTRAN UNITS)	O3 (SCALED LOWTRAN UNITS)	HNO3 (ATM CM)	O3 UV (ATM CM)	CNTMSLF1 (MOL CM-2)	CNTMSLF2 (MOL CM-2)	CNTMFRN (MOL CM-2)
1	70.000	217.85	7.454E-12	1.543E-07	2.560E-07	.000E+00	1.583E-05	3.036E+05	3.036E+05	1.085E+11
2	50.000	253.92	5.794E-09	1.702E-05	4.399E-05	.000E+00	9.672E-04	1.481E+09	1.481E+09	1.009E+14
3	45.000	267.09	2.987E-08	5.172E-05	1.853E-04	.000E+00	3.064E-03	1.159E+10	9.600E+09	3.350E+14
4	40.000	256.43	1.263E-07	1.650E-04	8.007E-04	7.727E-37	1.012E-02	6.443E+10	6.244E+10	2.517E+15

TABLE C-3 (Cont).

5	35.000	242.52	5.436E-07	5.659E-04	2.826E-03	1.055E-08	2.772E-02	3.377E+11	3.357E+11	1.191E+16
6	30.000	230.82	2.482E-06	2.072E-03	8.238E-03	5.493E-06	6.284E-02	1.885E+12	1.883E+12	6.086E+16
7	25.000	223.73	1.003E-05	7.878E-03	2.108E-02	4.040E-05	1.244E-01	7.829E+12	7.827E+12	2.651E+17
8	24.000	221.09	1.275E-05	1.032E-02	2.511E-02	5.660E-05	1.407E-01	9.649E+12	9.647E+12	3.422E+17
9	23.000	220.09	1.566E-05	1.353E-02	2.964E-02	7.864E-05	1.580E-01	1.122E+13	1.122E+13	4.262E+17
10	22.000	219.09	1.875E-05	1.776E-02	3.466E-02	1.002E-04	1.760E-01	1.256E+13	1.256E+13	5.171E+17
11	21.000	218.09	2.202E-05	2.335E-02	4.001E-02	1.215E-04	1.939E-01	1.369E+13	1.369E+13	6.150E+17
12	20.000	217.14	2.546E-05	3.074E-02	4.563E-02	1.427E-04	2.117E-01	1.465E+13	1.464E+13	7.207E+17
13	19.000	216.70	2.931E-05	4.049E-02	5.130E-02	1.622E-04	2.287E-01	1.552E+13	1.552E+13	8.394E+17
14	18.000	216.70	3.372E-05	5.331E-02	5.700E-02	1.814E-04	2.443E-01	1.639E+13	1.639E+13	9.783E+17
15	17.000	216.70	3.925E-05	7.018E-02	6.235E-02	2.022E-04	2.583E-01	1.743E+13	1.742E+13	1.155E+18
16	16.000	216.70	4.676E-05	9.237E-02	6.728E-02	2.254E-04	2.705E-01	1.886E+13	1.886E+13	1.399E+18
17	15.000	216.70	5.693E-05	1.216E-01	7.183E-02	2.512E-04	2.810E-01	2.085E+13	2.085E+13	1.735E+18
18	14.000	216.70	7.067E-05	1.600E-01	7.614E-02	2.789E-04	2.903E-01	2.359E+13	2.359E+13	2.196E+18
19	13.000	216.70	9.646E-05	2.106E-01	8.027E-02	3.074E-04	2.987E-01	3.108E+13	3.108E+13	3.076E+18
20	12.000	216.70	1.586E-04	2.772E-01	8.430E-02	3.363E-04	3.064E-01	6.376E+13	6.376E+13	5.229E+18
21	11.000	216.75	3.123E-04	3.649E-01	8.807E-02	3.621E-04	3.132E-01	2.154E+14	2.154E+14	1.064E+19
22	10.000	220.10	6.989E-04	4.776E-01	9.109E-02	3.787E-04	3.183E-01	9.514E+14	9.514E+14	2.432E+19
23	9.000	226.55	[illegible]	6.191E-01	9.343E-02	3.959E-04	3.221E-01	5.255E+15	5.255E+15	6.145E+19
24	8.000	233.00	4.811E-03	7.955E-01	9.532E-02	3.876E-04	3.249E-01	3.413E+16	3.413E+16	1.697E+20
25	7.000	239.50	1.196E-02	1.014E+00	9.696E-02	3.876E-04	3.273E-01	1.537E+17	1.537E+17	4.222E+20
26	6.000	246.00	2.625E-02	1.284E+00	9.856E-02	3.876E-04	3.295E-01	5.349E+17	5.349E+17	9.263E+20
27	5.000	252.50	5.402E-02	1.614E+00	1.002E-01	3.876E-04	3.316E-01	1.681E+18	1.681E+18	1.985E+21
28	4.000	258.99	1.057E-01	2.017E+00	1.019E-01	3.876E-04	3.337E-01	5.012E+18	5.012E+18	3.761E+21
29	3.000	265.49	2.048E-01	2.505E+00	1.038E-01	3.876E-04	3.360E-01	1.430E+19	1.288E+19	7.206E+21
30	2.000	271.99	3.811E-01	3.096E+00	1.060E-01	3.876E-04	3.384E-01	3.873E+19	2.918E+19	1.339E+22
31	1.000	278.49	6.778E-01	3.806E+00	1.083E-01	3.876E-04	3.409E-01	9.489E+19	5.649E+19	2.378E+22
32	.000	284.99	1.144E+00	4.657E+00	1.107E-01	3.876E-04	3.434E-01	2.087E+20	9.131E+19	4.007E+22

J	Z (KM)	N2 CONT	MOL SCAT	AER 1	AER 2	AER 3	AER 4	CIRRUS
1	70.000	9.534E-09	3.910E-04	.000E+00	.000E+00	.000E+00	9.272E-07	.000E+00
2	50.000	1.996E-06	6.294E-03	.000E+00	.000E+00	.000E+00	1.600E-05	.000E+00
3	45.000	7.117E-06	1.189E-02	.000E+00	.000E+00	.000E+00	3.076E-05	.000E+00
4	40.000	2.688E-05	2.296E-02	.000E+00	.000E+00	.000E+00	5.963E-05	.000E+00
5	35.000	1.104E-04	4.599E-02	.000E+00	.000E+00	.000E+00	1.181E-04	.000E+00
6	30.000	4.886E-04	9.551E-02	.000E+00	.000E+00	8.300E-05	1.591E-04	.000E+00
7	25.000	2.253E-03	2.033E-01	.000E+00	.000E+00	4.392E-04	1.591E-04	.000E+00
8	24.000	3.967E-03	2.369E-01	.000E+00	.000E+00	6.014E-04	1.591E-04	.000E+00
9	23.000	4.181E-03	2.762E-01	.000E+00	.000E+00	8.469E-04	1.591E-04	.000E+00
10	22.000	5.710E-03	3.224E-01	.000E+00	.000E+00	1.204E-03	1.591E-04	.000E+00
11	21.000	7.809E-03	3.765E-01	.000E+00	.000E+00	1.663E-03	1.591E-04	.000E+00
12	20.000	1.070E-02	4.400E-01	.000E+00	.000E+00	2.200E-03	1.591E-04	.000E+00
13	19.000	1.465E-02	5.145E-01	.000E+00	.000E+00	2.793E-03	1.591E-04	.000E+00
14	18.000	2.007E-02	6.016E-01	.000E+00	.000E+00	3.342E-03	1.591E-04	.000E+00
15	17.000	2.748E-02	7.035E-01	.000E+00	.000E+00	3.816E-03	1.591E-04	.000E+00
16	16.000	3.763E-02	8.227E-01	.000E+00	.000E+00	4.219E-03	1.591E-04	.000E+00
17	15.000	5.150E-02	9.621E-01	.000E+00	.000E+00	4.600E-03	1.591E-04	.000E+00

TABLE C-3 (Cont).

18	14.000	7.051E-02	1.125E+00	.000E+00	.000E+00	5.026E-03	1.591E-04	.000E+00
19	13.000	9.652E-02	1.316E+00	.000E+00	.000E+00	5.504E-03	1.591E-04	.000E+00
20	12.000	1.321E-01	1.539E+00	.000E+00	.000E+00	6.001E-03	1.591E-04	.000E+00
21	11.000	1.809E-01	1.901E+00	.000E+00	.000E+00	6.798E-03	1.591E-04	.000E+00
22	10.000	2.459E-01	2.101E+00	.000E+00	.000E+00	7.758E-03	1.591E-04	.000E+00
23	9.000	3.304E-01	2.442E+00	.000E+00	9.100E-04	8.328E-03	1.591E-04	.000E+00
24	8.000	4.393E-01	2.325E+00	.000E+00	3.426E-03	8.328E-03	1.591E-04	.000E+00
25	7.000	5.768E-01	3.257E+00	.000E+00	8.080E-03	8.328E-03	1.591E-04	.000E+00
26	6.000	7.563E-01	3.740E+00	.000E+00	1.502E-02	8.328E-03	1.591E-04	.000E+00
27	5.000	9.[illegible]E-01	4.[illegible]E+00	.000E+00	2.351E-02	8.328E-03	1.591E-04	.000E+00
28	4.[illegible]	1.263E+00	4.821E+00	.000E+00	3.689E-02	8.328E-03	1.591E-04	.000E+00
29	3.000	1.615E+00	5.545E+00	.000E+00	6.261E-02	8.328E-03	1.591E-04	.000E+00
30	2.000	2.053E+00	6.290E+00	3.105E-02	7.991E-02	8.328E-03	1.591E-04	.000E+00
31	1.000	2.595E+00	7.108E+00	3.122E-01	7.991E-02	8.328E-03	1.591E-04	.000E+00
32	.000	3.262E+00	8.012E+00	1.082E+00	7.991E-02	8.328E-03	1.591E-04	.000E+00

SUMMARY OF THE GEOMETRY CALCULATION

```
H1      =   100.000 KM
H2      =      .000 KM
ANGLE   =   180.000 DEG
RANGE   =   100.000 KM
BETA    =      .000 DEG
PHI     =      .000 DEG
HMIN    =      .000 KM
BENDING =      .000 DEG
LEN     =         0
```

EQUIVALENT SEA LEVEL TOTAL ABSORBER AMOUNTS

H2O	CO2+	O3	HNO3	O3 UV	CNTMSLF1	CNTMSLF2	CNTMFRN
(SCALED LOWTRAN UNITS)			(ATM CM)	(ATM CM)	(MOL CM-2)	(MOL CM-2)	(MOL CM-2)
1.144E+00	4.657E+00	1.107E-01	3.876E-04	3.434E-01	2.087E+20	9.131E+19	4.007E+22

N2 CONT	MOL SCAT	AER 1	AER 2	AER 3	AER 4	CIRRUS	MEAN RH (PRCNT)
3.262E+00	8.012E+00	1.082E+00	7.991E-02	8.328E-03	1.591E-04	.000E+00	48.25

TABLE C-3 (Cont).

RADIANCE(WATTS/CM2-STER-XXX)

FREQ (CM-1)	WAVLEN (MICRN)	ATMOS RADIANCE (CM-1)	(MICRN)	INTEGRAL (CM-1)	TOTAL TRANS
850.	11.765	1.04E-05	7.49E-04	2.59E-05	.7544
855.	11.696	1.03E-05	7.54E-04	7.75E-05	.7627
860.	11.628	1.02E-05	7.58E-04	1.29E-04	.7727
865.	11.561	1.02E-05	7.63E-04	1.80E-04	.7066
870.	11.494	1.01E-05	7.67E-04	2.30E-04	.7970
875.	11.429	1.00E-05	7.69E-04	2.81E-04	.7955
880.	11.364	9.96E-06	7.71E-04	3.30E-04	.7949
885.	11.299	9.88E-06	7.74E-04	3.80E-04	7966
890.	11.236	9.80E-06	7.76E-04	4.29E-04	.8010
895.	11.173	9.72E-06	7.79E-04	4.77E-04	.8043
900.	11.111	9.64E-06	7.81E-04	5.26E-04	.8084
905.	11.050	9.55E-06	7.82E-04	5.73E-04	.8053
910.	10.989	9.46E-06	7.83E-04	6.21E-04	.8043
915.	10.929	9.36E-06	7.84E-04	6.68E-04	.8028
920.	10.870	9.27E-06	7.84E-04	7.14E-04	.8035
925.	10.811	9.17E-06	7.85E-04	7.60E-04	.8133
930.	10.753	9.07E-06	7.85E-04	8.05E-04	.8116
935.	10.695	8.96E-06	7.83E-04	8.50E-04	.8079
940.	10.638	8.85E-06	7.82E-04	8.94E-04	.8024
945.	10.582	8.73E-06	7.79E-04	9.38E-04	.7932
950.	10.526	8.60E-06	7.76E-04	9.59E-04	.7857

INTEGRATED ABSORPTION FROM 850 TO 950 CM-1 = 20.32 CM-1

AVERAGE TRANSMITTANCE = .7968

INTEGRATED RADIANCE = 9.593E-04 WATTS CM-2 STER-1
MINIMUM RADIANCE = 8.599E-06 WATTS CM-2 STER-1 (CM-1)-1 AT 950.0 CM-1
MAXIMUM RADIANCE = 1.037E-05 WATTS CM-2 STER-1 (CM-1)-1 AT 850.0 CM-1
BOUNDARY TEMPERATURE = 288.20 K
BOUNDARY EMISSIVITY = 1.000

CARD 5 ***** 0

17.42.38.UCLP, AA, LP2 , 1.024KLNS.

TABLE C-4

LOWTRAN OUTPUT FOR CASE 3

```
                    ***** LOWTRAN 6 *****
CARD 1  *****    6    2    2    0    0    0    0    0       .000      .400    1
CARD 2  *****    2    0    0    0    0    0      .000      .000      .000      .000
CARD 3  *****      .000    20.000     .000      .000      .000      .000    0
CARD 3A1*****    2    2    1    0
CARD 3A2*****      .000    60.000     .000      .000      .000      .000      .000      .000
CARD 4  ***** 18100.000 18260.000    10.000
PROGRAM WILL COMPUTE RADIANCE+SOLAR SCATTERNG

CALCULATIONS WILL BE DONE USING MULTIPLE SCATTERING

ATMOSPHERIC MODEL
        TEMPERATURE =    6      1962 U S STANDARD
        WATER VAPOR =    6      1962 U S STANDARD
        OZONE       =    6      1962 U S STANDARD

AEROSOL MODEL
        REGIME                  AEROSOL TYPE              PROFILE                  SEASON

        BOUNDARY LAYER (0-2 KM) RURAL                      5.0 KM VIS AT SEA LEVEL
        TROPOSPHERE  (2-10KM)   TROPOSPHERIC              TROPOSPHERIC             SPRING-SUMMER
        STRATOSPHERE (10-30KM)  BACKGROUND STRATO         BACKGPOUND STRATO        SPRING-SUMMER
        UPPER ATMOS (30-100KM)  METEORIC DUST             NORMAL

SLANT PATH, H1 TO H2
        H1    =       .000 KM
        H2    =     20.000 KM
        ANGLE =       .000 DEG
        RANGE =       .000 KM
        BETA  =       .000 DEG
        LEN   =      0

SINGLE SCATTERING CONTROL PARAMETERS SUMMARY

        RELATIVE AZIMUTH =            .000 DEG EAST OF NORTH
        SOLAR ZENITH =              60.000 DEG
        TIME (<0 UNDEF) =             .000 GREENWICH TIME
        PATH AZIMUTH =                .000 DEG EAST OF NORTH
        DAY OF THE YEAR =            1

EXTRATERRESTIAL SOURCE IS THE SUN

PHASE FUNCTION FROM MIE DATA BASE

FREQUENCY RANGE
         V1 =      18100.0 CM-1  (        .55 MICROMETERS)
         V2 =      18260.0 CM-1  (        .55 MICROMETERS)
         DV =         10.0 CM-1
```

TABLE C-4 (Cont).

ATMOSPHERIC PROFILES

I	Z (KM)	P (MB)	T (K)	H2O	CO2+ (SCALED	O3 LOWTRAN UNITS)	N2	CNTMSLF (MOL/CM2 KM)	MOL SCAT (-)	N-1 (-)	O3 (UV) (ATM CM/KM)
1	.00	1013.000	288.2	5.758E-01	9.285E-01	2.493E-03	7.378E-01	1.569E+20	9.475E-01	2.774E-04	2.520E-03
2	1.00	898.800	281.7	3.719E-01	7.771E-01	2.387E-03	6.010E-01	7.951E+19	8.601E-01	2.519E-04	2.520E-03
3	2.00	795.000	275.2	2.323E-01	6.474E-01	2.284E-03	4.870E-01	3.791E+19	7.788E-01	2.281E-04	2.520E-03
4	3.00	701.200	268.7	1.302E-01	5.371E-01	2.020E-03	3.927E-01	1.460E+19	7.035E-01	2.061E-04	2.333E-03
5	4.00	616.600	262.2	7.166E-02	4.435E-01	1.774E-03	3.150E-01	5.454E+18	6.340E-01	1.857E-04	2.147E-03
6	5.00	540.500	255.7	3.745E-02	3.646E-01	1.692E-03	2.513E-01	1.846E+18	5.638E-01	1.670E-04	2.147E-03
7	6.00	472.200	249.2	1.992E-02	2.982E-01	1.576E-03	1.994E-01	5.508E+17	5.108E-01	1.497E-04	2.100E-03
8	7.00	411.100	242.7	9.834E-03	2.427E-01	1.632E-03	1.572E-01	1.988E+17	4.566E-01	1.338E-04	2.287E-03
9	8.00	356.500	236.2	5.004E-03	1.963E-01	1.645E-03	1.232E-01	6.490E+16	4.069E-01	1.192E-04	2.427E-03
10	9.00	308.000	229.7	1.703E-03	1.579E-01	2.130E-03	9.586E-02	9.537E+15	3.615E-01	1.059E-04	3.313E-03
11	10.00	265.000	223.3	5.894E-04	1.262E-01	2.557E-03	7.403E-02	1.460E+15	3.199E-01	9.376E-05	4.200E-03
12	11.00	227.000	216.8	2.367E-04	1.002E-01	3.493E-03	5.678E-02	3.031E+14	2.823E-01	8.272E-05	6.067E-03
13	12.00	194.000	216.7	9.275E-05	7.619E-02	4.037E-03	4.150E-02	6.170E+13	2.413E-01	7.073E-05	7.467E-03
14	13.00	165.800	216.7	3.917E-05	5.780E-02	4.028E-03	3.031E-02	1.460E+13	2.063E-01	6.045E-05	7.933E-03
15	14.00	141.700	216.7	1.587E-05	4.397E-02	4.228E-03	2.214E-02	3.180E+12	1.763E-01	5.166E-05	8.867E-03
16	15.00	121.100	216.7	1.181E-05	3.348E-02	4.388E-03	1.617E-02	2.337E+12	1.507E-01	4.415E-05	9.800E-03
17	16.00	103.500	216.7	8.687E-06	2.537E-02	4.710E-03	1.181E-02	1.677E+12	1.288E-01	3.774E-05	1.120E-02
18	17.00	88.500	216.7	6.432E-06	1.929E-02	5.161E-03	8.637E-03	1.219E+12	1.101E-01	3.227E-05	1.307E-02
19	18.00	75.650	216.7	4.726E-06	1.466E-02	5.540E-03	6.311E-03	8.726E+11	9.411E-02	2.758E-05	1.493E-02
20	19.00	64.670	216.7	4.104E-06	1.114E-02	5.691E-03	4.612E-03	8.726E+11	8.045E-02	2.358E-05	1.633E-02
21	20.00	55.290	216.7	3.564E-06	8.470E-03	5.803E-03	3.371E-03	8.726E+11	6.870E-02	2.016E-05	1.773E-02
22	21.00	47.290	217.6	3.371E-06	6.406E-03	5.447E-03	2.451E-03	1.030E+12	5.859E-02	1.717E-05	1.773E-02
23	22.00	40.470	218.6	3.168E-06	4.847E-03	5.248E-03	1.783E-03	1.219E+12	4.991E-02	1.463E-05	1.820E-02
24	23.00	34.670	219.6	3.015E-06	3.675E-03	4.802E-03	1.299E-03	1.464E+12	4.256E-02	1.247E-05	1.773E-02
25	24.00	29.720	220.6	2.883E-06	2.789E-03	4.274E-03	9.483E-04	1.677E+12	3.632E-02	1.064E-05	1.680E-02
26	25.00	25.490	221.6	2.636E-06	2.119E-03	3.792E-03	6.929E-04	1.963E+12	3.101E-02	9.088E-06	1.587E-02
27	30.00	11.970	226.5	7.612E-07	5.476E-04	1.642E-03	1.479E-04	6.508E+11	1.425E-02	4.175E-06	9.333E-03
28	35.00	5.746	236.5	1.624E-07	1.429E-04	6.674E-04	3.193E-05	1.154E+11	6.550E-03	1.920E-06	5.133E-03
29	40.00	2.871	250.4	3.549E-08	3.922E-05	2.227E-04	7.318E-06	2.023E+10	3.091E-03	9.059E-07	2.287E-03
30	45.00	1.491	264.2	9.176E-09	1.157E-05	5.881E-05	1.821E-06	4.615E+09	1.521E-03	4.459E-07	7.933E-04
31	50.00	.798	270.7	1.939E-09	3.747E-06	1.072E-05	5.027E-07	6.490E+08	7.945E-04	2.328E-07	1.867E-04
32	70.00	.055	219.7	2.406E-12	4.660E-08	8.259E-08	3.291E-09	1.014E+05	6.773E-05	1.985E-08	4.013E-06
33	100.00	.000	210.0	1.502E-16	5.420E-12	5.180E-12	1.046E-13	4.507E+00	3.861E-07	1.132E-10	2.007E-09

TABLE C-4 (Cont).

ATMOSPHERIC PROFILES

I	Z (KM)	P (MB)	T (K)	CNTMFRN MOL/CM2 KM	HNO3 ATM CM/KM	AEROSOL 1 (-)	AEROSOL 2 (-)	AEROSOL 3 (-)	AEROSOL 4 (-)	AEF1*RH (-)	CIRRUS (-)	RH (PERCNT)
1	.00	1013.000	288.2	2.010E+22	.000E+00	7.700E-01	.000E+00	.000E+00	.000E+00	3.533E+01	.000E+00	4.589E+01
2	1.00	898.800	281.7	1.301E+22	.000E+00	7.700E-01	.000E+00	.000E+00	.000E+00	3.777E+01	.000E+00	4.906E+01
3	2.00	795.000	275.2	9.143E+21	.000E+00	6.210E-02	.000E+00	.000E+00	.000E+00	3.230E+00	.000E+00	5.201E+01
4	3.00	701.200	268.7	4.573E+21	.000E+00	.000E+00	3.460E-02	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
5	4.00	616.600	262.2	2.521E+21	.000E+00	.000E+00	1.850E-02	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
6	5.00	540.500	255.7	1.319E+21	.000E+00	.000E+00	9.310E-03	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
7	6.00	472.200	249.2	7.025E+20	.000E+00	.000E+00	7.710E-03	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
8	7.00	411.100	242.7	3.472E+20	.000E+00	.000E+00	6.230E-03	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
9	8.00	356.500	236.2	1.768E+20	4.069E-35	.000E+00	3.370E-03	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
10	9.00	308.000	229.7	6.023E+19	3.615E-06	.000E+00	1.820E-03	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
11	10.00	265.000	223.3	2.086E+19	1.055E-05	.000E+00	.000E+00	1.140E-03	.000E+00	.000E+00	.000E+00	.000E+00
12	11.00	227.000	216.8	8.384E+18	2.258E-05	.000E+00	.000E+00	7.990E-04	.000E+00	.000E+00	.000E+00	.000E+00
13	12.00	194.000	216.7	3.235E+18	2.896E-05	.000E+00	.000E+00	6.410E-04	.000E+00	.000E+00	.000E+00	.000E+00
14	13.00	165.800	216.7	1.345E+18	2.888E-05	.000E+00	.000E+00	5.170E-04	.000E+00	.000E+00	.000E+00	.000E+00
15	14.00	141.700	216.7	5.364E+17	2.820E-05	.000E+00	.000E+00	4.420E-04	.000E+00	.000E+00	.000E+00	.000E+00
16	15.00	121.100	216.7	3.923E+17	2.712E-05	.000E+00	.000E+00	3.950E-04	.000E+00	.000E+00	.000E+00	.000E+00
17	16.00	103.500	216.7	2.845E+17	2.446E-05	.000E+00	.000E+00	3.870E-04	.000E+00	.000E+00	.000E+00	.000E+00
18	17.00	88.500	216.7	2.07[illegible]E+17	2.202E-05	.000E+00	.000E+00	4.250E-04	.000E+00	.000E+00	.000E+00	.000E+00
19	18.00	75.650	216.7	1.500E+17	1.976E-05	.000E+00	.000E+00	5.200E-04	.000E+00	.000E+00	.000E+00	.000E+00
20	19.00	64.670	216.7	1.282E+17	1.850E-05	.000E+00	.000E+00	5.810E-04	.000E+00	.000E+00	.000E+00	.000E+00
21	20.00	55.290	216.7	1.036E+17	2.063E-05	.000E+00	.000E+00	5.890E-04	.000E+00	.000E+00	.000E+00	.000E+00
22	21.00	47.290	217.6	1.019E+17	2.168E-05	.000E+00	.000E+00	5.020E-04	.000E+00	.000E+00	.000E+00	.000E+00
23	22.00	40.470	218.6	9.401E+16	2.096E-05	.000E+00	.000E+00	4.200E-04	.000E+00	.000E+00	.000E+00	.000E+00
24	23.00	34.670	219.6	8.788E+16	2.213E-05	.000E+00	.000E+00	3.000E-04	.000E+00	.000E+00	.000E+00	.000E+00
25	24.00	29.720	220.6	8.025E+16	2.179E-05	.000E+00	.000E+00	1.980E-04	.000E+00	.000E+00	.000E+00	.000E+00
26	25.00	25.490	221.6	7.414E+16	1.178E-05	.000E+00	.000E+00	1.310E-04	.000E+00	.000E+00	.000E+00	.000E+00
27	30.00	11.970	226.5	1.961E+16	3.704E-06	.000E+00	.000E+00	3.320E-05	.000E+00	.000E+00	.000E+00	.000E+00
28	35.00	5.746	236.5	3.796E+15	1.441E-07	.000E+00	.000E+00	.000E+00	1.640E-05	.000E+00	.000E+00	.000E+00
29	40.00	2.871	250.4	7.502E+14	3.891E-37	.000E+00	.000E+00	.000E+00	7.990E-06	.000E+00	.000E+00	.000E+00
30	45.00	1.491	264.2	1.764E+14	.000E+00	.000E+00	.000E+00	.000E+00	4.010E-06	.000E+00	.000E+00	.000E+00
31	50.00	.798	270.7	3.454E+13	.000E+00	.000E+00	.000E+00	.000E+00	2.100E-06	.000E+00	.000E+00	.000E+00
32	70.00	.055	219.7	3.680E+10	.000E+00	.000E+00	.000E+00	.000E+00	1.600E-07	.000E+00	.000E+00	.000E+00
33	100.00	.000	210.0	1.399E+06	.000E+00	.000E+00	.000E+00	.000E+00	9.310E-10	.000E+00	.000E+00	.000E+00

CASE 2A: GIVEN H1, H2, ANGLE

SLANT PATH PARAMETERS IN STANDARD FORM

H1	=	.000 KM
H2	=	20.000 KM
ANGLE	=	.000 DEG
PHI	=	180.000 DEG

TABLE C-4 (Cont).

HMIN : .000 KM
LEN : 0

TABLE C-4 (Cont).

CALCULATION OF THE REFRACTED PATH THROUGH THE ATMOSPHERE

I	ALTITUDE FROM (KM)	ALTITUDE TO (KM)	THETA (DEG)	DRANGE (KM)	RANGE (KM)	DBETA (DEG)	BETA (DEG)	PHI (DEG)	DBEND (DEG)	BENDING (DEG)	PBAR (MB)	TBAR (K)	RHOBAR (GM CM-3)
	H1 TO H2												
1	.000	1.000	.000	1.000	1.000	.000	.000	180.000	.000	.000	955.683	284.99	1.17E-03
2	1.000	2.000	.000	1.000	2.000	.000	.000	180.000	.000	.000	846.698	278.49	1.06E-03
3	2.000	3.000	.000	1.000	3.000	.000	.000	180.000	.000	.000	747.913	271.99	9.57E-04
4	3.000	4.000	.000	1.000	4.000	.000	.000	180.000	.000	.000	658.727	265.49	8.63E-04
5	4.000	5.000	.000	1.000	5.000	.000	.000	180.000	.000	.000	578.391	258.99	7.77E-04
6	5.000	6.000	.000	1.000	6.000	.000	.000	180.000	.000	.000	506.204	252.50	6.99E-04
7	6.000	7.000	.000	1.000	7.000	.000	.000	180.000	.000	.000	441.516	246.00	6.24E-04
8	7.000	8.000	.000	1.000	8.000	.000	.000	180.000	.000	.000	383.677	239.50	5.57E-04
9	8.000	9.000	.000	1.000	9.000	.000	.000	180.000	.000	.000	332.137	233.00	4.96E-04
10	9.000	10.000	.000	1.000	10.000	.000	.000	180.000	.000	.000	286.399	226.55	4.40E-04
11	10.000	11.000	.000	1.000	11.000	.000	.000	180.000	.000	.000	245.907	220.10	3.89E-04
12	11.000	12.000	.000	1.000	12.000	.000	.000	180.000	.000	.000	210.499	216.75	3.38E-04
13	12.000	13.000	.000	1.000	13.000	.000	.000	180.000	.000	.000	179.900	216.70	2.89E-04
14	13.000	14.000	.000	1.000	14.000	.000	.000	180.000	.000	.000	153.750	216.70	2.47E-04
15	14.000	15.000	.000	1.000	15.000	.000	.000	180.000	.000	.000	131.400	216.70	2.11E-04
16	15.000	16.000	.000	1.000	16.000	.000	.000	180.000	.000	.000	112.300	216.70	1.80E-04
17	16.000	17.000	.000	1.000	17.000	.000	.000	180.000	.000	.000	96.000	216.70	1.54E-04
18	17.000	18.000	.000	1.000	18.000	.000	.000	180.000	.000	.000	82.075	216.70	1.32E-04
19	18.000	19.000	.000	1.000	19.000	.000	.000	180.000	.000	.000	70.160	216.70	1.13E-04
20	19.000	20.000	.000	1.000	20.000	.000	.000	180.000	.000	.000	59.980	216.70	9.62E-05

CUMULATIVE ABSORBER AMOUNTS FOR THE PATH FROM H1 TO Z

J	Z (KM)	TBAR (K)	H2O (SCALED LOWTRAN UNITS)	CO2+ (SCALED LOWTRAN UNITS)	O3 (SCALED LOWTRAN UNITS)	HNO3 (ATM CM)	O3 UV (ATM CM)	CNTMSLF1 (MOL CM-2)	CNTMSLF2 (MOL CM-2)	CNTMFRN (MOL CM-2)
1	1.000	284.99	4.664E-01	8.506E-01	2.440E-03	.000E+00	2.520E-03	1.138E+20	3.482E+19	1.629E+22
2	2.000	278.49	7.631E-01	1.561E+00	4.775E-03	.000E+00	5.040E-03	1.700E+20	6.213E+19	2.668E+22
3	3.000	271.99	9.394E-01	2.151E+00	6.924E-03	.000E+00	7.465E-03	1.944E+20	7.842E+19	3.287E+22
4	4.000	265.49	1.037E+00	2.640E+00	8.819E-03	.000E+00	9.704E-03	2.037E+20	8.630E+19	3.631E+22
5	5.000	258.99	1.090E+00	3.043E+00	1.055E-02	.000E+00	1.185E-02	2.071E+20	8.963E+19	3.817E+22
6	6.000	252.50	1.118E+00	3.373E+00	1.218E-02	.000E+00	1.397E-02	2.082E+20	9.077E+19	3.915E+22
7	7.000	246.00	1.132E+00	3.643E+00	1.379E-02	.000E+00	1.617E-02	2.086E+20	9.115E+19	3.965E+22
8	8.000	239.50	1.139E+00	3.861E+00	1.543E-02	2.034E-35	1.852E-02	2.087E+20	9.127E+19	3.990E+22
9	9.000	233.00	1.142E+00	4.038E+00	1.732E-02	1.887E-06	2.139E-02	2.087E+20	9.130E+19	4.001E+22
10	10.000	226.55	1.144E+00	4.179E+00	1.966E-02	8.893E-06	2.515E-02	2.087E+20	9.131E+19	4.005E+22
11	11.000	220.10	1.144E+00	4.292E+00	2.268E-02	2.546E-05	3.028E-02	2.087E+20	9.131E+19	4.006E+22
12	12.000	216.75	1.144E+00	4.380E+00	2.645E-02	5.123E-05	3.705E-02	2.087E+20	9.131E+19	4.007E+22
13	13.000	216.70	1.144E+00	4.446E+00	3.048E-02	8.015E-05	4.475E-02	2.087E+20	9.131E+19	4.007E+22
14	14.000	216.70	1.144E+00	4.497E+00	3.461E-02	1.087E-04	5.315E-02	2.087E+20	9.131E+19	4.007E+22
15	15.000	216.70	1.144E+00	4.535E+00	3.892E-02	1.363E-04	6.248E-02	2.087E+20	9.131E+19	4.007E+22

TABLE C-4 (Cont).

16	16.000	216.70	1.144E+00	4.565E+00	4.347E-02	1.621E-04	7.298E-02	2.087E+20	9.131E+19	4.007E+22
17	17.000	216.70	1.144E+00	4.587E+00	4.840E-02	1.853E-04	8.512E-02	2.087E+20	9.131E+19	4.007E+22
18	18.000	216.70	1.144E+00	4.604E+00	5.375E-02	2.062E-04	9.912E-02	2.087E+20	9.131E+19	4.007E+22
19	19.000	216.70	1.144E+00	4.616E+00	5.937E-02	2.253E-04	1.148E-01	2.087E+20	9.131E+19	4.007E+22
20	20.000	216.70	1.144E+00	4.626E+00	6.512E-02	2.449E-04	1.318E-01	2.087E+20	9.131E+19	4.007E+22

J	Z (KM)	N2 CONT	MOL SCAT	AER 1	AER 2	AER 3	AER 4	CIRRUS
1	1.000	6.671E-01	9.031E-01	7.700E-01	.000E+00	.000E+00	.000E+00	.000E+00
2	2.000	1.209E+00	1.722E+00	1.051E+00	.000E+00	.000E+00	.000E+00	.000E+00
3	3.000	1.647E+00	2.462E+00	1.082E+00	1.730E-02	.000E+00	.000E+00	.000E+00
4	4.000	2.000E+00	3.131E+00	1.082E+00	4.382E-02	.000E+00	.000E+00	.000E+00
5	5.000	2.282E+00	3.732E+00	1.082E+00	5.640E-02	.000E+00	.000E+00	.000E+00
6	6.000	2.506E+00	4.272E+00	1.082E+00	6.488E-02	.000E+00	.000E+00	.000E+00
7	7.000	2.683E+00	4.755E+00	1.082E+00	7.183E-02	.000E+00	.000E+00	.000E+00
8	8.000	2.823E+00	5.186E+00	1.082E+00	7.648E-02	.000E+00	.000E+00	.000E+00
9	9.000	2.932E+00	5.570E+00	1.082E+00	7.900E-02	.000E+00	.000E+00	.000E+00
10	10.000	3.016E+00	5.910E+00	1.082E+00	7.991E-02	5.700E-04	.000E+00	.000E+00
11	11.000	3.081E+00	6.211E+00	1.082E+00	7.991E-02	1.529E-03	.000E+00	.000E+00
12	12.000	3.130E+00	6.472E+00	1.082E+00	7.991E-02	2.247E-03	.000E+00	.000E+00
13	13.000	3.166E+00	6.695E+00	1.082E+00	7.991E-02	2.823E-03	.000E+00	.000E+00
14	14.000	3.192E+00	6.886E+00	1.082E+00	7.991E-02	3.302E-03	.000E+00	.000E+00
15	15.000	3.211E+00	7.049E+00	1.082E+00	7.991E-02	3.720E-03	.000E+00	.000E+00
16	16.000	3.225E+00	7.189E+00	1.082E+00	7.991E-02	4.108E-03	.000E+00	.000E+00
17	17.000	3.235E+00	7.308E+00	1.082E+00	7.991E-02	4.512E-03	.000E+00	.000E+00
18	18.000	3.242E+00	7.410E+00	1.082E+00	7.991E-02	4.984E-03	.000E+00	.000E+00
19	19.000	3.248E+00	7.497E+00	1.082E+00	7.991E-02	5.535E-03	.000E+00	.000E+00
20	20.000	3.252E+00	7.571E+00	1.082E+00	7.991E-02	6.120E-03	.000E+00	.000E+00

SUMMARY OF THE GEOMETRY CALCULATION

```
H1      =      .000 KM
H2      =    20.000 KM

ANGLE   =      .000 DEG
RANGE   =    20.000 KM
BETA    =      .000 DEG
PHI     =   180.000 DEG
HMIN    =      .000 KM
BENDING =      .000 DEG
LEN     =         0
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EQUIVALENT SEA LEVEL TOTAL ABSORBER AMOUNTS

H2O (SCALED LOWTRAN UNITS)	CO2+ (SCALED LOWTRAN UNITS)	O3 (SCALED LOWTRAN UNITS)	HNO3 (ATM CM)	O3 UV (ATM CM)	CNTMSLF1 (MOL CM-2)	CNTMSLF2 (MOL CM-2)	CNTMFRN (MOL CM-2)
1.144E+00	4.626E+00	6.512E-02	2.449E-04	1.318E-01	2.087E+20	9.131E+19	4.007E+22

TABLE C-4 (Cont).

N2 CONT	MOL SCAT	AER 1	AER 2	AER 3	AER 4	CIRRUS	MEAN RH (PRCNT)
3.252E+00	7.571E+00	1.082E+00	7.991E-02	6.120E-03	.000E+00	.000E+00	48.25

SINGLE SCATTERING POINT TO SOURCE PATHS

SCTTR POINT	SCTTR ALT	SUBTENDED ANGLE	SOLAR ZENITH	PATH ZENITH	RELATIVE AZIMUTH	SCTTR ANGLE	MOLECULAR PHASE F
1	.00	.00	60.00	.00	1	60.00	.748E-01
2	1.00	.00	60.00	.00	1	60.00	.748E-01
3	2.00	.00	60.00	.00	1	60.00	.748E-01
4	3.00	.00	60.00	.00	1	60.00	.748E-01
5	4.00	.00	60.00	.00	1	60.00	.748E-01
6	5.00	.00	60.00	.00	1	60.00	.748E-01
7	6.00	.00	60.00	.00	1	60.00	.748E-01
8	7.00	.00	60.00	.00	1	60.00	.748E-01
9	8.00	.00	60.00	.00	1	60.00	.748E-01
10	9.00	.00	60.00	.00	1	60.00	.748E-01
11	10.00	.00	60.00	.00	1	60.00	.748E-01
12	11.00	.00	60.00	.00	1	60.00	.748E-01
13	12.00	.00	60.00	.00	1	60.00	.748E-01
14	13.00	.00	60.00	.00	1	60.00	.748E-01
15	14.00	.00	60.00	.00	1	60.00	.748E-01
16	15.00	.00	60.00	.00	1	60.00	.748E-01
17	16.00	.00	60.00	.00	1	60.00	.748E-01
18	17.	.00	60.00	.00	1	60.00	.748E-01
19	18.	.00	60.00	.00	1	60.00	.748E-01
20	19.00	.00	60.00	.00	1	60.00	.748E-01
21	20.00	.00	60.00	.00	1	60.00	.748E-01

CASE 2A: GIVEN H1, H2, ANGLE

SLANT PATH PARAMETERS IN STANDARD FORM

H1	=	.000 KM
H2	=	100.000 KM
ANGLE	=	.000 DEG
PHI	=	180.000 DEG
HMIN	=	.000 KM
LEN	=	0

TABLE C-4 (Cont).

CALCULATION OF THE REFRACTED PATH THROUGH THE ATMOSPHERE

I	ALTITUDE FROM (KM)	ALTITUDE TO (KM)	THETA (DEG)	DRANGE (KM)	RANGE (KM)	DBETA (DEG)	BETA (DEG)	PHI (DEG)	DBEND (DEG)	BENDING (DEG)	PBAR (MB)	TBAR (K)	RHOBAR (GM CM-3)
	H1 TO H2												
1	.000	1.000	.000	1.000	1.000	.000	.000	180.000	.000	.000	955.683	284.99	1.17E-03
2	1.000	2.000	.000	1.000	2.000	.000	.000	180.000	.000	.000	846.698	278.49	1.06E-03
3	2.000	3.000	.000	1.000	3.000	.000	.000	180.000	.000	.000	747.913	271.99	9.57E-04
4	3.000	4.000	.000	1.000	4.000	.000	.000	180.000	.000	.000	658.727	265.49	8.63E-04
5	4.000	5.000	.000	1.000	5.000	.000	.000	180.000	.000	.000	578.391	258.99	7.77E-04
6	5.000	6.000	.000	1.000	6.000	.000	.000	180.000	.000	.000	506.204	252.50	6.98E-04
7	6.000	7.000	.000	1.000	7.000	.000	.000	180.000	.000	.000	441.516	246.00	6.24E-04
8	7.000	8.000	.000	1.000	8.000	.000	.000	180.000	.000	.000	383.677	239.50	5.57E-04
9	8.000	9.000	.000	1.000	9.000	.000	.000	180.000	.000	.000	332.137	233.00	4.96E-04
10	9.000	10.000	.000	1.000	10.000	.000	.000	180.000	.000	.000	286.399	226.55	4.40E-04
11	10.000	11.000	.000	1.000	11.000	.000	.000	180.000	.000	.000	245.907	220.10	3.89E-04
12	11.000	12.000	.000	1.000	12.000	.000	.000	180.000	.000	.000	210.499	216.75	3.38E-04
13	12.000	13.000	.000	1.000	13.000	.000	.000	180.000	.000	.000	179.900	216.70	2.89E-04
14	13.000	14.000	.000	1.000	14.000	.000	.000	180.000	.000	.000	153.750	216.70	2.47E-04
15	14.000	15.000	.000	1.000	15.000	.000	.000	180.000	.000	.000	131.400	216.70	2.11E-04
16	15.000	16.000	.000	1.000	16.000	.000	.000	180.000	.000	.000	112.300	216.70	1.80E-04
17	16.000	17.000	.000	1.000	17.000	.000	.000	180.000	.000	.000	96.000	216.70	1.54E-04
18	17.000	18.000	.000	1.000	18.000	.000	.000	180.000	.000	.000	82.075	216.70	1.32E-04
19	18.000	19.000	.000	1.000	19.000	.000	.000	180.000	.000	.000	70.160	216.70	1.13E-04
20	19.000	20.000	.000	1.000	20.000	.000	.000	180.000	.000	.000	59.980	216.70	9.62E-05
21	20.000	21.000	.000	1.000	21.000	.000	.000	180.000	.000	.000	51.293	217.14	8.21E-05
22	21.000	22.000	.000	1.000	22.000	.000	.000	180.000	.000	.000	43.883	218.09	7.00E-05
23	22.000	23.000	.000	1.000	23.000	.000	.000	180.000	.000	.000	37.572	219.09	5.96E-05
24	23.000	24.000	.000	1.000	24.000	.000	.000	180.000	.000	.000	32.197	220.09	5.09E-05
25	24.000	25.000	.000	1.000	25.000	.000	.000	180.000	.000	.000	27.607	221.09	4.34E-05
26	25.000	30.000	.000	5.000	30.000	.000	.000	180.000	.000	.000	18.754	223.73	2.79E-05
27	30.000	35.000	.000	5.000	35.000	.000	.000	180.000	.000	.000	8.880	230.82	1.28E-05
28	35.000	40.000	.000	5.000	40.000	.000	.000	180.000	.000	.000	4.322	242.52	5.95E-06
29	40.000	45.000	.000	5.000	45.000	.000	.000	180.000	.000	.000	2.187	256.43	2.86E-06
30	45.000	50.000	.000	5.000	50.000	.000	.000	180.000	.000	.000	1.146	267.09	1.45E-06
31	50.000	70.000	.000	20.000	70.000	.000	.000	180.000	.000	.000	.416	253.92	3.81E-07
32	70.000	100.000	.000	30.000	100.000	.000	.000	180.000	.000	.000	.028	217.85	1.68E-08

CUMULATIVE ABSORBER AMOUNTS FOR THE PATH FROM H1 TO Z

	Z (KM)	TBAR (K)	H2O (SCALED LOWTRAN UNITS)	CO2+ (SCALED LOWTRAN UNITS)	O3 (SCALED LOWTRAN UNITS)	HNO3 (ATM CM)	O3 UV (ATM CM)	CNTMSLF1 (MOL CM-2)	CNTMSLF2 (MOL CM-2)	CNTMFRN (MOL CM-2)
1	1.000	284.99	4.664E-01	8.506E-01	2.440E-03	.000E+00	2.520E-03	1.138E+20	3.482E+19	1.629E+22
2	2.000	278.49	7.631E-01	1.561E+00	4.775E-03	.000E+00	5.040E-03	1.700E+20	6.213E+19	2.668E+22
3	3.000	271.99	9.394E-01	2.161E+00	6.924E-03	.000E+00	7.465E-03	1.944E+20	7.842E+19	3.287E+22
4	4.000	265.49	1.037E+00	2.640E+00	8.819E-03	.000E+00	9.704E-03	2.037E+20	8.630E+19	3.631E+22

TABLE C-4 (Cont).

5	5.000	258.99	1.090E+00	3.043E+00	1.055E-02	.000E+00	1.185E-02	2.071E+20	8.963E+19	3.817E+22
6	6.000	252.50	1.118E+00	3.373E+00	1.218E-02	.000E+00	1.397E-02	2.082E+20	9.077E+19	3.915E+22
7	7.000	246.00	1.132E+00	3.643E+00	1.379E-02	.000E+00	1.617E-02	2.086E+20	9.115E+19	3.965E+22
8	8.000	239.50	1.139E+00	3.861E+00	1.543E-02	2.034E-35	1.852E-02	2.087E+20	9.127E+19	3.990E+22
9	9.000	233.00	1.142E+00	4.030E+00	1.732E-02	1.807E-06	2.139E-02	2.087E+20	9.130E+19	4.001E+22
10	10.000	226.55	1.144E+00	4.179E+00	1.966E-02	8.893E-06	2.515E-02	2.087E+20	9.131E+19	4.005E+22
11	11.000	220.10	1.144E+00	4.292E+00	2.268E-02	2.546E-05	3.028E-02	2.087E+20	9.131E+19	4.006E+22
12	12.000	216.75	1.144E+00	4.380E+00	2.645E-02	5.123E-05	3.705E-02	2.087E+20	9.131E+19	4.007E+22
13	13.000	216.70	1.144E+00	4.446E+00	3.048E-02	8.015E-05	4.475E-02	2.087E+20	9.131E+19	4.007E+22
14	14.000	216.70	1.144E+00	4.497E+00	3.461E-02	1.087E-04	5.315E-02	2.087E+20	9.131E+19	4.007E+22
15	15.000	216.70	1.144E+00	4.535E+00	3.892E-02	1.363E-04	6.248E-02	2.087E+20	9.131E+19	4.007E+22
16	16.000	216.70	1.144E+00	4.565E+00	4.347E-02	1.621E-04	7.298E-02	2.087E+20	9.131E+19	4.007E+22
17	17.000	216.70	1.144E+00	4.587E+00	4.840E-02	1.853E-04	8.512E-02	2.087E+20	9.131E+19	4.007E+22
18	18.000	216.70	1.144E+00	4.604E+00	5.375E-02	2.062E-04	9.912E-02	2.087E+20	9.131E+19	4.007E+22
19	19.000	216.70	1.144E+00	4.616E+00	5.937E-02	2.253E-04	1.148E-01	2.087E+20	9.131E+19	4.007E+22
20	20.000	216.70	1.144E+00	4.626E+00	6.512E-02	2.449E-04	1.318E-01	2.087E+20	9.131E+19	4.007E+22
21	21.000	217.14	1.144E+00	4.634E+00	7.074E-02	2.661E-04	1.495E-01	2.087E+20	9.131E+19	4.007E+22
22	22.000	218.09	1.144E+00	4.639E+00	7.609E-02	2.874E-04	1.675E-01	2.087E+20	9.131E+19	4.007E+22
23	23.000	219.09	1.144E+00	4.643E+00	8.111E-02	3.089E-04	1.854E-01	2.087E+20	9.131E+19	4.007E+22
24	24.000	220.09	1.144E+00	4.647E+00	8.564E-02	3.309E-04	2.027E-01	2.087E+20	9.131E+19	4.007E+22
25	25.000	221.09	1.144E+00	4.649E+00	8.967E-02	3.472E-04	2.190E-01	2.087E+20	9.131E+19	4.007E+22
26	30.000	223.72	1.144E+00	4.655E+00	1.025E-01	3.821E-04	2.806E-01	2.087E+20	9.131E+19	4.007E+22
27	35.000	230.82	1.144E+00	4.656E+00	1.079E-01	3.875E-04	3.157E-01	2.087E+20	9.131E+19	4.007E+22
28	40.000	242.52	1.144E+00	4.657E+00	1.099E-01	3.876E-04	3.333E-01	2.087E+20	9.131E+19	4.007E+22
29	45.000	256.43	1.144E+00	4.657E+00	1.106E-01	3.876E-04	3.404E-01	2.087E+20	9.131E+19	4.007E+22
30	50.000	267.09	1.144E+00	4.657E+00	1.107E-01	3.876E-04	3.425E-01	2.087E+20	9.131E+19	4.007E+22
31	70.000	253.92	1.144E+00	4.657E+00	1.107E-01	3.876E-04	3.434E-01	2.087E+20	9.131E+19	4.007E+22
32	100.000	217.85	1.144E+00	4.657E+00	1.107E-01	3.876E-04	3.434E-01	2.087E+20	9.131E+19	4.007E+22

I	Z (KM)	N2 CONT	MOL SCAT	AER 1	AER 2	AER 3	AER 4	CIRRUS
1	1.000	6.671E-01	9.031E-01	7.700E-01	.000E+00	.000E+00	.000E+00	.000E+00
2	2.000	1.209E+00	1.722E+00	1.651E+00	.000E+00	.000E+00	.000E+00	.000E+00
3	3.000	1.647E+00	2.462E+00	1.082E+00	1.730E-02	.000E+00	.000E+00	.000E+00
4	4.000	2.000E+00	3.131E+00	1.082E+00	4.302E-02	.000E+00	.000E+00	.000E+00
5	5.000	2.282E+00	3.732E+00	1.082E+00	5.640E-02	.000E+00	.000E+00	.000E+00
6	6.000	2.506E+00	4.272E+00	1.082E+00	6.488E-02	.000E+00	.000E+00	.000E+00
7	7.000	2.683E+00	4.755E+00	1.082E+00	7.183E-02	.000E+00	.000E+00	.000E+00
8	8.000	2.823E+00	5.186E+00	1.082E+00	7.648E-02	.000E+00	.000E+00	.000E+00
9	9.000	2.932E+00	5.570E+00	1.082E+00	7.900E-02	.000E+00	.000E+00	.000E+00
10	10.000	3.016E+00	5.910E+00	1.082E+00	7.991E-02	5.700E-04	.000E+00	.000E+00
11	11.000	3.081E+00	6.211E+00	1.082E+00	7.991E-02	1.529E-03	.000E+00	.000E+00
12	12.000	3.130E+00	6.472E+00	1.082E+00	7.991E-02	2.247E-03	.000E+00	.000E+00
13	13.000	3.166E+00	6.695E+00	1.082E+00	7.991E-02	2.823E-03	.000E+00	.000E+00
14	14.000	3.192E+00	6.886E+00	1.082E+00	7.991E-02	3.302E-03	.000E+00	.000E+00
15	15.000	3.211E+00	7.049E+00	1.082E+00	7.991E-02	3.728E-03	.000E+00	.000E+00
16	16.000	3.225E+00	7.189E+00	1.082E+00	7.991E-02	4.108E-03	.000E+00	.000E+00
17	17.000	3.235E+00	7.309E+00	1.082E+00	7.991E-02	4.512E-03	.000E+00	.000E+00

TABLE C-4 (Cont).

18	18.000	3.242E+00	7.410E+00	1.082E+00	7.991E-02	4.984E-03	.000E+00	.000E+00
19	19.000	3.248E+00	7.497E+00	1.082E+00	7.991E-02	5.535E-03	.000E+00	.000E+00
20	20.000	3.252E+00	7.571E+00	1.082E+00	7.991E-02	6.120E-03	.000E+00	.000E+00
21	21.000	3.254E+00	7.635E+00	1.082E+00	7.991E-02	6.664E-03	.000E+00	.000E+00
22	22.000	3.257E+00	7.689E+00	1.082E+00	7.991E-02	7.124E-03	.000E+00	.000E+00
23	23.000	3.258E+00	7.735E+00	1.082E+00	7.991E-02	7.481E-03	.000E+00	.000E+00
24	24.000	3.259E+00	7.775E+00	1.082E+00	7.991E-02	7.726E-03	.000E+00	.000E+00
25	25.000	3.260E+00	7.808E+00	1.082E+00	7.991E-02	7.868E-03	.000E+00	.000E+00
26	30.000	3.262E+00	7.916E+00	1.082E+00	7.991E-02	8.245E-03	.000E+00	.000E+00
27	35.000	3.262E+00	7.966E+00	1.082E+00	7.991E-02	8.328E-03	4.100E-05	.000E+00
28	40.000	3.262E+00	7.989E+00	1.082E+00	7.991E-02	8.328E-03	9.948E-05	.000E+00
29	45.000	3.262E+00	8.000E+00	1.082E+00	7.991E-02	8.328E-03	1.283E-04	.000E+00
30	50.000	3.262E+00	8.005E+00	1.082E+00	7.991E-02	8.329E-03	1.431E-04	.000E+00
31	70.000	3.262E+00	8.011E+00	1.082E+00	7.991E-02	8.328E-03	1.582E-04	.000E+00
32	100.000	3.262E+00	8.012E+00	1.082E+00	7.991E-02	8.328E-03	1.591E-04	.000E+00

SUMMARY OF THE GEOMETRY CALCULATION

H1	=	.000 KM
H2	=	100.000 KM
ANGLE	=	.000 DEG
RANGE	=	100.000 KM
BETA	=	.000 DEG
PHI	=	180.000 DEG
HMIN	=	.000 KM
BENDING	=	.000 DEG
LEN	=	0

EQUIVALENT SEA LEVEL TOTAL ABSORBER AMOUNTS

H2O	CO2+	O3	HNO3	O3 UV	CNTMSLF1	CNTMSLF2	CNTMFRN
(SCALED LOWTRAN UNITS)			(ATM CM)	(ATM CM)	(MOL CM-2)	(MOL CM-2)	(MOL CM-2)
1.144E+00	4.657E+00	1.107E-01	3.876E-04	3.434E-01	2.007E+20	9.131E+19	4.007E+22

N2 CONT	MOL SCAT	AER 1	AER 2	AER 3	AER 4	CIRRUS	MEAN RH (PRCNT)
3.262E+00	8.012E+00	1.082E+00	7.991E-02	8.328E-03	1.591E-04	.000E+00	48.25

SINGLE SCATTERING POINT TO SOURCE PATHS

SCTTR POINT	SCTTR ALT	SUBTENDED ANGLE	SOLAR ZENITH	PATH ZENITH	RELATIVE AZIMUTH	SCTTR ANGLE	MOLECULAR PHASE F
1	.00	.00	60.00	.00	1	60.00	.748E-01
2	1.00	.00	60.00	.00	1	60.00	.748E-01
3	2.00	.00	60.00	.00	1	60.00	.748E-01
4	3.00	.00	60.00	.00	1	60.00	.748E-01
5	4.00	.00	60.00	.00	1	60.00	.748E-01
6	5.00	.00	60.00	.00	1	60.00	.748E-01

TABLE C-4 (Cont).

7	6.00	.00	60.00	.00	I	60.00	.748E-01
8	7.00	.00	60.00	.00	I	60.00	.748E-01
9	8.00	.00	60.00	.00	I	60.00	.748E-01
10	9.00	.00	60.00	.00	I	60.00	.748E-01
11	10.00	.00	60.00	.00	I	60.00	.748E-01
12	11.00	.00	60.00	.00	I	60.00	.748E-01
13	12.00	.00	60.00	.00	I	60.00	.748E-01
14	13.00	.00	60.00	.00	I	60.00	.748E-01
15	14.00	.00	60.00	.00	I	60.00	.748E-01
16	15.00	.00	60.00	.00	I	60.00	.748E-01
17	16.00	.00	60.00	.00	I	60.00	.748E-01
18	17.00	.00	60.00	.00	I	60.00	.748E-01
19	18.00	.00	60.00	.00	I	60.00	.748E-01
20	19.00	.00	60.00	.00	I	60.00	.748E-01
21	20.00	.00	60.00	.00	I	60.00	.748E-01
22	21.00	.00	60.00	.00	I	60.00	.748E-01
23	22.00	.00	60.00	.00	I	60.00	.748E-01
24	23.00	.00	60.00	.00	I	60.00	.748E-01
25	24.00	.00	60.00	.00	I	60.00	.748E-01
26	25.00	.00	60.00	.00	I	60.00	.748E-01
27	30.00	.00	60.00	.00	I	60.00	.748E-01
28	35.00	.00	60.00	.00	I	60.00	.748E-01
29	40.00	.00	60.00	.00	I	60.00	.748E-01
30	45.00	.00	60.00	.00	I	60.00	.748E-01
31	50.00	.00	60.00	.00	I	60.00	.748E-01
32	70.00	.00	60.00	.00	I	60.00	.748E-01
33	100.00	.00	60.00	.00	I	60.00	.748E-01

TABLE C-4 (Cont).

RADIANCE(WATTS/CM2-STER-XXX)

FREQ	WAVLEN	ATMOS RADIANCE		PATH SCATTERED RADIANCE TOTAL		PATH SCATTERED RADIANCE S SCAT	GROUND REFLECTED RADIANCE TOTAL		GROUND REFLECTED RADIANCE DIRECT	TOTAL RADIANCE		INTEGRAL	TOTAL
(CM-1)	(MICRN)	(CM-1)	(MICRN)	(CM-1)	(MICRN)	(CM-1)	(CM-1)	(MICRN)	(CM-1)	(CM-1)	(MICRN)	(CM-1)	TRANS
18100.	.552	5.26E-40	1.72E-35	3.05E-07	1.00E-02	8.09E-08	.00E+00	.00E+00	.00E+00	3.05E-07	1.00E-02	1.53E-06	.2820
18110.	.552	5.01E-40	1.64E-35	3.05E-07	1.00E-02	8.08E-08	.00E+00	.00E+00	.00E+00	3.05E-07	1.00E-02	4.58E-06	.2818
18120.	.552	4.78E-40	1.57E-35	3.05E-07	1.00E-02	8.07E-08	.00E+00	.00E+00	.00E+00	3.05E-07	1.00E-02	7.63E-06	.2816
18130.	.552	4.56E-40	1.50E-35	3.05E-07	1.00E-02	8.07E-08	.00E+00	.00E+00	.00E+00	3.05E-07	1.00E-02	1.07E-05	.2813
18140.	.551	4.34E-40	1.43E-35	3.05E-07	1.00E-02	8.06E-08	.00E+00	.00E+00	.00E+00	3.05E-07	1.00E-02	1.37E-05	.2811
18150.	.551	4.14E-40	1.36E-35	3.05E-07	1.00E-02	8.05E-08	.00E+00	.00E+00	.00E+00	3.05E-07	1.00E-02	1.68E-05	.2809
18160.	.551	3.95E-40	1.30E-35	3.05E-07	1.00E-02	8.04E-08	.00E+00	.00E+00	.00E+00	3.05E-07	1.00E-02	1.98E-05	.2807
18170.	.550	3.77E-40	1.24E-35	3.05E-07	1.01E-02	8.03E-08	.00E+00	.00E+00	.00E+00	3.05E-07	1.01E-02	2.29E-05	.2805
18180.	.550	3.59E-40	1.19E-35	3.05E-07	1.01E-02	8.03E-08	.00E+00	.00E+00	.00E+00	3.05E-07	1.01E-02	2.59E-05	.2803
18190.	.550	3.42E-40	1.13E-35	3.05E-07	1.01E-02	8.03E-08	.00E+00	.00E+00	.00E+00	3.05E-07	1.01E-02	2.90E-05	.2800
18200.	.549	3.27E-40	1.08E-35	3.05E-07	1.01E-02	8.02E-08	.00E+00	.00E+00	.00E+00	3.05E-07	1.01E-02	3.20E-05	.2797
18210.	.549	3.12E-40	1.03E-35	3.05E-07	1.01E-02	8.02E-08	.00E+00	.00E+00	.00E+00	3.05E-07	1.01E-02	3.51E-05	.2793
18220.	.549	2.97E-40	9.85E-36	3.05E-07	1.01E-02	8.01E-08	.00E+00	.00E+00	.00E+00	3.05E-07	1.01E-02	3.81E-05	.2790
18230.	.549	2.83E-40	9.42E-36	3.05E-07	1.01E-02	8.01E-08	.00E+00	.00E+00	.00E+00	3.05E-07	1.01E-02	4.12E-05	.2787
18240.	.548	2.70E-40	8.99E-36	3.06E-07	1.02E-02	8.00E-08	.00E+00	.00E+00	.00E+00	3.06E-07	1.02E-02	4.42E-05	.2783
18250.	.548	2.58E-40	8.56E-36	3.06E-07	1.02E-02	7.99E-08	.00E+00	.00E+00	.00E+00	3.06E-07	1.02E-02	4.73E-05	.2780
18260.	.548	2.46E-40	8.20E-36	3.06E-07	1.02E-02	7.99E-08	.00E+00	.00E+00	.00E+00	3.06E-07	1.02E-02	4.88E-05	.2777

INTEGRATED ABSORPTION FROM18100 TO18260 CM-1 = 115.19 CM-1
AVERAGE TRANSMITTANCE = .2801

INTEGRATED RADIANCE = 4.881E-05 WATTS CM-2 STER-1
MINIMUM RADIANCE = 3.045E-07 WATTS CM-2 STER-1 (CM-1)-1 AT 18100.0 CM-1

MAXIMUM RADIANCE = 3.058E-07 WATTS CM-2 STER-1 (CM-1)-1 AT 18260.0 CM-1
BOUNDARY TEMPERATURE = .00 K
BOUNDARY EMISSIVITY = .600

CARD 5 ***** 0

16.43.38.UCLP, AA, LP2 , 1.024KLNS.

TABLE C-5

LOWTRAN OUTPUT FOR CASE 4

```
                 ***** LOWTRAN 5 *****
CARD 1   *****   6    2    2    0    0    0    0    0      .000      .400     1
CARD 2   *****   2    0    0    0    0    0     .000      .000      .000      .000
CARD 3   *****   20.000      .000   180.000     .020      .000      .000     0
CARD 3A1*****    2    2    1    0
CARD 3A2*****      .000    60.000      .000     .000      .000      .000      .000      .000
CARD 4   ***** 18100.000 18260.000    10.000
PROGRAM WILL COMPUTE RADIANCE+SOLAR SCATTERNG

CALCULATIONS WILL BE DONE USING MULTIPLE SCATTERING

ATMOSPHERIC MODEL
        TEMPERATURE =    6      1962 U S STANDARD
        WATER VAPOR =    6      1962 U S STANDARD
        OZONE       =    6      1962 U S STANDARD

AEROSOL MODEL
        REGIME                  AEROSOL TYPE            PROFILE                  SEASON

        BOUNDARY LAYER (0-2 KM) RURAL                     5.0 KM VIS AT SEA LEVEL
        TROPOSPHERE  (2-10KM)   TROPOSPHERIC            TROPOSPHERIC             SPRING-SUMMER
        STRATOSPHERE (10-30KM)  BACKGROUND STRATO       BACKGROUND STRATO        SPRING-SUMMER
        UPPER ATMOS (30-100KM)  METEORIC DUST           NORMAL

SLANT PATH, H1 TO H2
        H1     =     20.000 KM
        H2     =       .000 KM
        ANGLE  =    180.000 DEG
        RANGE  =       .000 KM
        BETA   =       .000 DEG
        LEN    =      0

SINGLE SCATTERING CONTROL PARAMETERS SUMMARY

        RELATIVE AZIMUTH =           .000 DEG EAST OF NORTH
        SOLAR ZENITH =             60.000 DEG
        TIME (<0 UNDEF) =            .000 GREENWICH TIME
        PATH AZIMUTH =               .000 DEG EAST OF NORTH
        DAY OF THE YEAR =           1

EXTRATERRESTIAL SOURCE IS THE SUN

PHASE FUNCTION FROM MIE DATA BASE

FREQUENCY RANGE
         V1 =      18100.0 CM-1  (        .55 MICROMETERS)
         V2 =      18260.0 CM-1  (        .55 MICROMETERS)
         DV =         10.0 CM-1
```

TABLE C-5 (Cont).

ATMOSPHERIC PROFILES

I	Z (KM)	P (MB)	T (K)	H2O	CO2+ (SCALED	O3 LOWTRAN UNITS)	N2	CNTMSLF (MOL/CM2 KM)	MOL SCAT (-)	N-1 (-)	O3 (UV) (ATM CM/KM)
1	.00	1013.000	288.2	5.758E-01	9.285E-01	2.493E-03	7.378E-01	1.569E+20	9.475E-01	2.774E-04	2.520E-03
2	1.00	898.800	281.7	3.719E-01	7.771E-01	2.387E-03	6.010E-01	7.951E+19	8.601E-01	2.519E-04	2.520E-03
3	2.00	795.000	275.2	2.323E-01	6.474E-01	2.284E-03	4.870E-01	3.791E+19	7.788E-01	2.281E-04	2.520E-03
4	3.00	701.200	268.7	1.302E-01	5.371E-01	2.020E-03	3.927E-01	1.460E+19	7.035E-01	2.061E-04	2.333E-03
5	4.00	616.600	262.2	7.166E-02	4.435E-01	1.774E-03	3.150E-01	5.454E+18	6.340E-01	1.857E-04	2.147E-03
6	5.00	540.500	255.7	3.745E-02	3.646E-01	1.692E-03	2.513E-01	1.846E+18	5.698E-01	1.670E-04	2.147E-03
7	6.00	472.200	249.2	1.992E-02	2.982E-01	1.576E-03	1.994E-01	6.500E+17	5.100E-01	1.497E-04	2.100E-03
8	7.00	411.100	242.7	9.834E-03	2.427E-01	1.632E-03	1.572E-01	1.988E+17	4.566E-01	1.338E-04	2.287E-03
9	8.00	356.500	236.2	5.004E-03	1.963E-01	1.645E-03	1.232E-01	6.490E+16	4.069E-01	1.192E-04	2.427E-03
10	9.00	308.000	229.7	1.703E-03	1.579E-01	2.130E-03	9.586E-02	9.537E+15	3.615E-01	1.059E-04	3.313E-03
11	10.00	265.000	223.3	5.894E-04	1.262E-01	2.557E-03	7.403E-02	1.460E+15	3.199E-01	9.376E-05	4.200E-03
12	11.00	227.000	216.8	2.367E-04	1.002E-01	3.493E-03	5.678E-02	3.031E+14	2.823E-01	8.272E-05	6.067E-03
13	12.00	194.000	216.7	9.275E-05	7.619E-02	4.037E-03	4.150E-02	6.170E+13	2.413E-01	7.073E-05	7.467E-03
14	13.00	165.800	216.7	3.917E-05	5.788E-02	4.028E-03	3.031E-02	1.460E+13	2.063E-01	6.045E-05	7.933E-03
15	14.00	141.700	216.7	1.587E-05	4.397E-02	4.220E-03	2.214E-02	3.180E+12	1.763E-01	5.166E-05	8.867E-03
16	15.00	121.100	216.7	1.181E-05	3.340E-02	4.388E-03	1.617E-02	2.337E+12	1.507E-01	4.415E-05	9.800E-03
17	16.00	103.500	216.7	8.687E-06	2.537E-02	4.710E-03	1.181E-02	1.677E+12	1.288E-01	3.774E-05	1.120E-02
18	17.00	88.500	216.7	6.432E-05	1.929E-02	5.161E-03	8.637E-03	1.219E+12	1.101E-01	3.227E-05	1.307E-02
19	18.00	75.650	216.7	4.726E-06	1.466E-02	5.540E-03	6.311E-03	8.726E+11	9.411E-02	2.758E-05	1.493E-02
20	19.00	64.670	216.7	4.104E-06	1.114E-02	5.691E-03	4.612E-03	8.726E+11	8.045E-02	2.358E-05	1.633E-02
21	20.00	55.290	216.7	3.564E-06	8.470E-03	5.803E-03	3.371E-03	8.726E+11	6.878E-02	2.016E-05	1.773E-02
22	21.00	47.290	217.6	3.371E-06	6.486E-03	5.447E-03	2.451E-03	1.038E+12	5.859E-02	1.717E-05	1.773E-02
23	22.00	40.470	218.6	3.168E-06	4.847E-03	5.248E-03	1.703E-03	1.219E+12	4.991E-02	1.463E-05	1.820E-02
24	23.00	34.670	219.6	3.015E-06	3.675E-03	4.802E-03	1.299E-03	1.464E+12	4.256E-02	1.247E-05	1.773E-02
25	24.00	29.720	220.6	2.803E-06	2.789E-03	4.274E-03	9.483E-04	1.677E+12	3.632E-02	1.064E-05	1.698E-02
26	25.00	25.490	221.6	2.636E-06	2.119E-03	3.792E-03	6.929E-04	1.963E+12	3.101E-02	9.088E-06	1.587E-02
27	30.00	11.970	226.5	7.612E-07	5.476E-04	1.542E-03	1.479E-04	6.508E+11	1.425E-02	4.175E-06	9.333E-03
28	35.00	5.746	236.5	1.624E-07	1.429E-04	6.674E-04	3.193E-05	1.154E+11	6.550E-03	1.920E-06	5.133E-03
29	40.00	2.871	250.4	3.549E-08	3.922E-05	2.227E-04	7.318E-06	2.023E+10	3.091E-03	9.059E-07	2.287E-03
30	45.00	1.491	264.2	9.176E-09	1.157E-05	5.881E-05	1.821E-06	4.615E+09	1.521E-03	4.459E-07	7.933E-04
31	50.00	.798	270.7	1.939E-09	3.747E-06	1.072E-05	5.027E-07	6.490E+08	7.945E-04	2.328E-07	1.867E-04
32	70.00	.055	219.7	2.406E-12	4.660E-08	8.259E-08	3.291E-09	1.014E+05	6.773E-05	1.985E-08	4.013E-06
33	100.00	.000	210.0	1.502E-16	5.420E-12	5.180E-12	1.046E-13	4.507E+00	3.861E-07	1.132E-10	2.007E-09

ATMOSPHERIC PROFILES

I	Z (KM)	P (MB)	T (K)	CNTMFRN MOL/CM2 KM	HNO3 ATM CM/KM	AEROSOL 1 (-)	AEROSOL 2 (-)	AEROSOL 3 (-)	AEROSOL 4 (-)	AER1*RH (-)	CIRRUS (-)	RH (PERCNT)
1	.00	1013.000	288.2	2.010E+22	.000E+00	7.700E-01	.000E+00	.000E+00	.000E+00	3.533E+01	.000E+00	4.589E+01
2	1.00	898.800	281.7	1.301E+22	.000E+00	7.700E-01	.000E+00	.000E+00	.000E+00	3.777E+01	.000E+00	4.906E+01
3	2.00	795.000	275.2	8.143E+21	.000E+00	6.210E-02	.000E+00	.000E+00	.000E+00	3.230E+00	.000E+00	5.201E+01
4	3.00	701.200	268.7	4.573E+21	.000E+00	.000E+00	3.460E-02	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
5	4.00	616.600	262.2	2.521E+21	.000E+00	.000E+00	1.050E-02	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
6	5.00	540.500	255.7	1.319E+21	.000E+00	.000E+00	9.310E-03	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
7	6.00	472.200	249.2	7.025E+20	.000E+00	.000E+00	7.710E-03	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
8	7.00	411.100	242.7	3.472E+20	.000E+00	.000E+00	6.230E-03	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
9	8.00	356.500	236.2	1.768E+20	4.069E-35	.000E+00	3.370E-03	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
10	9.00	308.000	229.7	6.023E+19	3.615E-06	.000E+00	1.070E-03	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
11	10.00	265.000	223.3	2.086E+19	1.056E-05	.000E+00	.000E+00	1.140E-03	.000E+00	.000E+00	.000E+00	.000E+00
12	11.00	227.000	216.8	8.384E+18	2.258E-05	.000E+00	.000E+00	7.990E-04	.000E+00	.000E+00	.000E+00	.000E+00
13	12.00	194.000	216.7	3.235E+18	2.896E-05	.000E+00	.000E+00	6.410E-04	.000E+00	.000E+00	.000E+00	.000E+00
14	13.00	165.800	216.7	1.345E+18	2.808E-05	.000E+00	.000E+00	5.170E-04	.000E+00	.000E+00	.000E+00	.000E+00
15	14.00	141.700	216.7	5.364E+17	2.820E-05	.000E+00	.000E+00	4.420E-04	.000E+00	.000E+00	.000E+00	.000E+00
16	15.00	121.100	216.7	3.929E+17	2.712E-05	.000E+00	.000E+00	3.950E-04	.000E+00	.000E+00	.000E+00	.000E+00
17	16.00	103.500	216.7	2.845E+17	2.446E-05	.000E+00	.000E+00	3.820E-04	.000E+00	.000E+00	.000E+00	.000E+00
18	17.00	88.500	216.7	2.074E+17	2.202E-05	.000E+00	.000E+00	4.250E-04	.000E+00	.000E+00	.000E+00	.000E+00
19	18.00	75.650	216.7	1.500E+17	1.976E-05	.000E+00	.000E+00	5.200E-04	.000E+00	.000E+00	.000E+00	.000E+00
20	19.00	64.670	216.7	1.282E+17	1.850E-05	.000E+00	.000E+00	5.810E-04	.000E+00	.000E+00	.000E+00	.000E+00
21	20.00	55.290	216.7	1.096E+17	2.063E-05	.000E+00	.000E+00	5.890E-04	.000E+00	.000E+00	.000E+00	.000E+00
22	21.00	47.290	217.6	1.019E+17	2.168E-05	.000E+00	.000E+00	5.020E-04	.000E+00	.000E+00	.000E+00	.000E+00
23	22.00	40.470	218.6	9.401E+16	2.096E-05	.000E+00	.000E+00	4.200E-04	.000E+00	.000E+00	.000E+00	.000E+00
24	23.00	34.670	219.6	8.788E+16	2.213E-05	.000E+00	.000E+00	3.000E-04	.000E+00	.000E+00	.000E+00	.000E+00
25	24.00	29.720	220.6	8.025E+16	2.179E-05	.000E+00	.000E+00	1.980E-04	.000E+00	.000E+00	.000E+00	.000E+00
26	25.00	25.490	221.6	7.414E+16	1.170E-05	.000E+00	.000E+00	1.310E-04	.000E+00	.000E+00	.000E+00	.000E+00
27	30.00	11.970	226.5	1.961E+16	3.704E-06	.000E+00	.000E+00	3.326E-05	.000E+00	.000E+00	.000E+00	.000E+00
28	35.00	5.746	236.5	3.796E+15	1.441E-07	.000E+00	.000E+00	.000E+00	1.640E-05	.000E+00	.000E+00	.000E+00
29	40.00	2.871	250.4	7.502E+14	3.091E-37	.000E+00	.000E+00	.000E+00	7.990E-06	.000E+00	.000E+00	.000E+00
30	45.00	1.491	264.2	1.764E+14	.000E+00	.000E+00	.000E+00	.000E+00	4.010E-06	.000E+00	.000E+00	.000E+00
31	50.00	.798	270.7	3.454E+13	.000E+00	.000E+00	.000E+00	.000E+00	2.100E-06	.000E+00	.000E+00	.000E+00
32	70.00	.055	219.7	3.600E+10	.000E+00	.000E+00	.000E+00	.000E+00	1.600E-07	.000E+00	.000E+00	.000E+00
33	100.00	.000	210.0	1.399E+06	.000E+00	.000E+00	.000E+00	.000E+00	9.310E-10	.000E+00	.000E+00	.000E+00

CASE 2A: GIVEN H1, H2, ANGLE

EITHER A SHORT PATH (LEN=0) OR A LONG PATH THROUGH A TANGENT HEIGHT (LEN=1) IS POSSIBLE: LEN = 0

SLANT PATH PARAMETERS IN STANDARD FORM

TABLE C-5 (Cont).

```
H1     =     20.000 KM
H2     =       .000 KM
ANGLE  =    180.000 DEG
PHI    =       .000 DEG
HMIN   =       .000 KM
LEN    =          0
```

TABLE C-5 (Cont).

CALCULATION OF THE REFRACTED PATH THROUGH THE ATMOSPHERE

I	ALTITUDE FROM (KM)	ALTITUDE TO (KM)	THETA (DEG)	DRANGE (KM)	RANGE (KM)	DBETA (DEG)	BETA (DEG)	PHI (DEG)	DBEND (DEG)	BENDING (DEG)	PBAR (MB)	TBAR (K)	RHOBAR (GM CM-3)
	H2 TO H1												
1	.000	1.000	.000	1.000	1.000	.000	.000	180.000	.000	.000	955.683	284.99	1.17E-03
2	1.000	2.000	.000	1.000	2.000	.000	.000	180.000	.000	.000	846.698	278.49	1.06E-03
3	2.000	3.000	.000	1.000	3.000	.000	.000	180.000	.000	.000	747.913	271.99	9.57E-04
4	3.000	4.000	.000	1.000	4.000	.000	.000	180.000	.000	.000	658.727	265.49	8.63E-04
5	4.000	5.000	.000	1.000	5.000	.000	.000	180.000	.000	.000	578.391	258.99	7.77E-04
6	5.000	6.000	.000	1.000	6.000	.000	.000	180.000	.000	.000	506.204	252.50	6.98E-04
7	6.000	7.000	.000	1.000	7.000	.000	.000	180.000	.000	.000	441.516	246.00	6.24E-04
8	7.000	8.000	.000	1.000	8.000	.000	.000	180.000	.000	.000	383.677	239.50	5.57E-04
9	8.000	9.000	.000	1.000	9.000	.000	.000	180.000	.000	.000	332.137	233.00	4.96E-04
10	9.000	10.000	.000	1.000	10.000	.000	.000	180.000	.000	.000	286.399	226.55	4.40E-04
11	10.000	11.000	.000	1.000	11.000	.000	.000	180.000	.000	.000	245.987	220.10	3.89E-04
12	11.000	12.000	.000	1.000	12.000	.000	.000	180.000	.000	.000	210.499	216.75	3.38E-04
13	12.000	13.000	.000	1.000	13.000	.000	.000	180.000	.000	.000	179.900	216.70	2.89E-04
14	13.000	14.000	.000	1.000	14.000	.000	.000	180.000	.000	.000	153.750	216.70	2.47E-04
15	14.000	15.000	.000	1.000	15.000	.000	.000	180.000	.000	.000	131.400	216.70	2.11E-04
16	15.000	16.000	.000	1.000	16.000	.000	.000	180.000	.000	.000	112.300	216.70	1.80E-04
17	16.000	17.000	.000	1.000	17.000	.000	.000	180.000	.000	.000	96.000	216.70	1.54E-04
18	17.000	18.000	.000	1.000	18.000	.000	.000	180.000	.000	.000	82.075	216.70	1.32E-04
19	18.000	19.000	.000	1.000	19.000	.000	.000	180.000	.000	.000	70.160	216.70	1.13E-04
20	19.000	20.000	.000	1.000	20.000	.000	.000	180.000	.000	.000	59.980	216.70	3.62E-05

CUMULATIVE ABSORBER AMOUNTS FOR THE PATH FROM H1 TO Z

J	Z (KM)	TBAP (K)	H2O (SCALED LOWTRAN UNITS)	CO2+ (SCALED LOWTRAN UNITS)	O3 (SCALED LOWTRAN UNITS)	HNO3 (ATM CM)	O3 UV (ATM CM)	CNTMSLF1 (MOL CM-2)	CNTMSLF2 (MOL CM-2)	CNTMFRN (MOL CM-2)
1	19.000	216.70	3.828E-06	9.745E-03	5.747E-03	1.957E-05	1.703E-02	8.726E+11	8.726E+11	1.187E+17
2	18.000	216.70	8.235E-06	2.257E-02	1.136E-02	3.870E-05	3.267E-02	1.745E+12	1.745E+12	2.575E+17
3	17.000	216.70	1.377E-05	3.944E-02	1.671E-02	5.957E-05	4.667E-02	2.781E+12	2.781E+12	4.347E+17
4	16.000	216.70	2.127E-05	6.163E-02	2.165E-02	8.279E-05	5.880E-02	4.217E+12	4.217E+12	6.786E+17
5	15.000	216.70	3.144E-05	9.083E-02	2.620E-02	1.086E-04	6.930E-02	6.206E+12	6.206E+12	1.014E+18
6	14.000	216.70	4.518E-05	1.293E-01	3.051E-02	1.362E-04	7.863E-02	8.942E+12	8.942E+12	1.475E+18
7	13.000	216.70	7.097E-05	1.799E-01	3.463E-02	1.647E-04	8.703E-02	1.644E+13	1.644E+13	2.355E+18
8	12.000	216.70	1.331E-04	2.465E-01	3.867E-02	1.937E-04	9.473E-02	4.912E+13	4.912E+13	4.508E+18
9	11.000	216.75	2.868E-04	3.342E-01	4.243E-02	2.194E-04	1.015E-01	2.008E+14	2.008E+14	9.915E+18
10	10.000	220.10	6.734E-04	4.469E-01	4.545E-02	2.368E-04	1.066E-01	9.367E+14	9.367E+14	2.360E+19
11	9.000	226.55	1.723E-03	5.883E-01	4.780E-02	2.431E-04	1.104E-01	5.241E+15	5.241E+15	6.073E+19
12	8.000	233.00	4.785E-03	7.647E-01	4.969E-02	2.449E-04	1.133E-01	3.411E+16	3.411E+16	1.690E+20
13	7.000	239.50	1.193E-02	9.834E-01	5.133E-02	2.449E-04	1.156E-01	1.537E+17	1.537E+17	4.215E+20
14	6.000	246.00	2.622E-02	1.253E+00	5.293E-02	2.449E-04	1.178E-01	5.348E+17	5.348E+17	9.256E+20

TABLE C-5 (Cont).

15	5.000	252.50	5.399E-02	1.583E+00	5.456E-02	2.449E-04	1.199E-01	1.681E+18	1.681E+18	1.904E+21
16	4.000	258.99	1.067E-01	1.986E+00	5.630E-02	2.449E-04	1.221E-01	5.012E+18	5.012E+18	3.760E+21
17	3.000	265.49	2.047E-01	2.475E+00	5.819E-02	2.449E-04	1.243E-01	1.430E+19	1.288E+19	7.285E+21
18	2.000	271.99	3.811E-01	3.065E+00	6.034E-02	2.449E-04	1.267E-01	3.873E+19	2.918E+19	1.339E+22
19	1.000	278.49	6.778E-01	3.776E+00	6.268E-02	2.449E-04	1.293E-01	9.489E+19	5.649E+19	2.378E+22
20	.000	284.99	1.144E+00	4.626E+00	6.512E-02	2.449E-04	1.318E-01	2.087E+20	9.131E+19	4.007E+22

J	Z (KM)	N2 CONT	MOL SCAT	AER 1	AER 2	AER 3	AER 4	CIRRUS
1	19.000	3.959E-03	7.446E-02	.000E+00	.000E+00	5.850E-04	.000E+00	.000E+00
2	18.000	9.376E-03	1.616E-01	.000E+00	.000E+00	1.136E-03	.000E+00	.000E+00
3	17.000	1.679E-02	2.635E-01	.000E+00	.000E+00	1.600E-03	.000E+00	.000E+00
4	16.000	2.693E-02	3.826E-01	.000E+00	.000E+00	2.012E-03	.000E+00	.000E+00
5	15.000	4.081E-02	5.221E-01	.000E+00	.000E+00	2.400E-03	.000E+00	.000E+00
6	14.000	5.981E-02	6.852E-01	.000E+00	.000E+00	2.818E-03	.000E+00	.000E+00
7	13.000	8.587E-02	8.761E-01	.000E+00	.000E+00	3.297E-03	.000E+00	.000E+00
8	12.000	1.214E-01	1.099E+00	.000E+00	.000E+00	3.873E-03	.000E+00	.000E+00
9	11.000	1.702E-01	1.361E+00	.000E+00	.000E+00	4.590E-03	.000E+00	.000E+00
10	10.000	2.352E-01	1.661E+00	.000E+00	.000E+00	5.550E-03	.000E+00	.000E+00
11	9.000	3.197E-01	2.002E+00	.000E+00	9.100E-04	6.120E-03	.000E+00	.000E+00
12	8.000	4.286E-01	2.385E+00	.000E+00	3.426E-03	6.120E-03	.000E+00	.000E+00
13	7.000	5.681E-01	2.817E+00	.000E+00	8.080E-03	6.120E-03	.000E+00	.000E+00
14	6.000	7.456E-01	3.300E+00	.000E+00	1.502E-02	6.120E-03	.000E+00	.000E+00
15	5.000	9.790E-01	3.840E+00	.000E+00	2.351E-02	6.120E-03	.000E+00	.000E+00
16	4.000	1.252E+00	4.441E+00	.000E+00	3.689E-02	6.120E-03	.000E+00	.000E+00
17	3.000	1.604E+00	5.109E+00	.000E+00	6.261E-02	6.120E-03	.000E+00	.000E+00
18	2.000	2.042E+00	5.850E+00	3.105E-02	7.991E-02	6.120E-03	.000E+00	.000E+00
19	1.000	2.585E+00	6.668E+00	3.122E-01	7.991E-02	6.120E-03	.000E+00	.000E+00
20	.000	3.252E+00	7.571E+00	1.082E+00	7.991E-02	6.120E-03	.000E+00	.000E+00

SUMMARY OF THE GEOMETRY CALCULATION

```
H1      =   20.000 KM
H2      =     .000 KM

ANGLE   =  180.000 DEG
RANGE   =   20.000 KM
BETA    =     .090 DEG
PHI     =     .000 DEG
HMIN    =     .000 KM
BENDING =     .003 DEG
LEN     =        0
```

EQUIVALENT SEA LEVEL TOTAL ABSORBER AMOUNTS

H2O	CO2+	O3	HNO3	O3 UV	CNTMSLF1	CNTMSLF2	CNTMFRN
(SCALED LOWTRAN UNITS)			(ATM CM)	(ATM CM)	(MOL CM-2)	(MOL CM-2)	(MOL CM-2)

TABLE C-5 (Cont).

N2 CONT	MOL SCAT	AER 1	AER 2	AER 3	AER 4	CIRRUS	MEAN RH (PRCNT)
1.144E+00	4.626E+00	6.512E-02	2.449E-04	1.318E-01	2.007E+20	9.131E+19	4.007E+22
3.252E+00	7.571E+00	1.082E+00	7.991E-02	6.120E-03	.000E+00	.000E+00	[illegible]3.25

SINGLE SCATTERING POINT TO SOURCE PATHS

SCTTR POINT	SCTTR ALT	SUBTENDED ANGLE	SOLAR ZENITH	PATH ZENITH	RELATIVE AZIMUTH	SCTTR ANGLE	MOLECULAR PHASE F
1	20.00	.00	60.00	180.00	1	120.00	.748E-01
2	19.00	.00	60.00	180.00	1	120.00	.748E-01
3	18.00	.00	60.00	180.00	1	120.00	.748E-01
4	17.00	.00	60.00	180.00	1	120.00	.748E-01
5	16.00	.00	60.00	180.00	1	120.00	.748E-01
6	15.00	.00	60.00	180.00	1	120.00	.748E-01
7	14.00	.00	60.00	180.00	1	120.00	.748E-01
8	13.00	.00	60.00	180.00	1	120.00	.748E-01
9	12.00	.00	60.00	180.00	1	120.00	.748E-01
10	11.00	.00	60.00	180.00	1	120.00	.748E-01
11	10.00	.00	60.00	180.00	1	120.00	.748E-01
12	9.00	.00	60.00	180.00	1	120.00	.748E-01
13	8.00	.00	60.00	180.00	1	120.00	.748E-01
14	7.00	.00	60.00	180.00	1	120.00	.748E-01
15	6.00	.00	60.00	180.00	1	120.00	.748E-01
16	5.00	.00	60.00	180.00	1	120.00	.748E-01
17	4.00	.00	60.00	180.00	1	120.00	.748E-01
18	3.00	.00	60.00	180.00	1	120.00	.748E-01
19	2.00	.00	60.00	180.00	1	120.00	.748E-01
20	1.00	.00	60.00	180.00	1	120.00	.748E-01
21	.00	.00	60.00	180.00	1	120.00	.748E-01

CASE 2D: GIVEN H1, H2, BETA:

ITERATE AROUND ANGLE UNTIL BETA CONVERGES

ITER	ANGLE (DEG)	BETA (DEG)	DBETA (DEG)	RANGE (KM)	HMIN (KM)	PHI (DEG)	BENDING (DEG)
1	.0000	.0000	.0000	100.000	.000	180.0000	.0000
2	.0000	.0000	.0000	100.000	.000	180.0000	.0000

SLANT PATH PARAMETERS IN STANDARD FORM

```
H1     =   100.000 KM
H2     =      .000 KM
ANGLE  =   180.000 DEG

PHI    =      .000 DEG
HMIN   =      .000 KM
LEN    =         0
```

TABLE C-5 (Cont).

CALCULATION OF THE REFRACTED PATH THROUGH THE ATMOSPHERE

I	ALTITUDE FROM (KM)	TO (KM)	THETA (DEG)	DRANGE (KM)	RANGE (KM)	DBETA (DEG)	BETA (DEG)	PHI (DEG)	DBEND (DEG)	BENDING (DEG)	PBAR (MB)	TBAR (K)	RHOBAR (GM CM-3)
	H2 TO H1												
1	.000	1.000	.000	1.000	1.000	.000	.000	180.000	.000	.000	955.683	284.99	1.17E-03
2	1.000	2.000	.000	1.000	2.000	.000	.000	180.000	.000	.000	846.698	278.49	1.06E-03
3	2.000	3.000	.000	1.000	3.000	.000	.000	180.000	.000	.000	747.913	271.99	9.57E-04
4	3.000	4.000	.000	1.000	4.000	.000	.000	180.000	.000	.000	658.727	265.49	8.63E-04
5	4.000	5.000	.000	1.000	5.000	.000	.000	180.000	.000	.000	578.391	258.99	7.77E-04
6	5.000	6.000	.000	1.000	6.000	.000	.000	180.000	.000	.000	506.204	252.50	6.98E-04
7	6.000	7.000	.000	1.000	7.000	.000	.000	180.000	.000	.000	441.516	246.00	6.24E-04
8	7.000	8.000	.000	1.000	8.000	.000	.000	180.000	.000	.000	383.677	239.50	5.57E-04
9	8.000	9.000	.000	1.000	9.000	.000	.000	180.000	.000	.000	332.137	233.00	4.96E-04
10	9.000	10.000	.000	1.000	10.000	.000	.000	180.000	.000	.000	286.399	226.55	4.40E-04
11	10.000	11.000	.000	1.000	11.000	.000	.000	180.000	.000	.000	245.907	220.10	3.89E-04
12	11.000	12.000	.000	1.000	12.000	.000	.000	180.000	.000	.000	210.499	216.75	3.38E-04
13	12.000	13.000	.000	1.000	13.000	.000	.000	180.000	.000	.000	179.900	216.70	2.89E-04
14	13.000	14.000	.000	1.000	14.000	.000	.000	180.000	.000	.000	153.750	216.70	2.47E-04
15	14.000	15.000	.000	1.000	15.000	.000	.000	180.000	.000	.000	131.400	216.70	2.11E-04
16	15.000	16.000	.000	1.000	16.000	.000	.000	180.000	.000	.000	112.300	216.70	1.80E-04
17	16.000	17.000	.000	1.000	17.000	.000	.000	180.000	.000	.000	96.000	216.70	1.54E-04
18	17.000	18.000	.000	1.000	18.000	.000	.000	180.000	.000	.000	82.075	216.70	1.32E-04
19	18.000	19.000	.000	1.000	19.000	.000	.000	180.000	.000	.000	70.160	216.70	1.13E-04
20	19.000	20.000	.000	1.000	20.000	.000	.000	180.000	.000	.000	59.980	216.70	9.62E-05
21	20.000	21.000	.000	1.000	21.000	.000	.000	180.000	.000	.000	51.293	217.14	8.21E-05
22	21.000	22.000	.000	1.000	22.000	.000	.000	180.000	.000	.000	43.883	218.09	7.00E-05
23	22.000	23.000	.000	1.000	23.000	.000	.000	180.000	.000	.000	37.572	219.09	5.96E-05
24	23.000	24.000	.000	1.000	24.000	.000	.000	180.000	.000	.000	32.197	220.09	5.09E-05
25	24.000	25.000	.000	1.000	25.000	.000	.000	180.000	.000	.000	27.607	221.09	4.34E-05
26	25.000	30.000	.000	5.000	30.000	.000	.000	180.000	.000	.000	18.754	223.73	2.79E-05
27	30.000	35.000	.000	5.000	35.000	.000	.000	180.000	.000	.000	8.880	230.82	1.28E-05
28	35.000	40.000	.000	5.000	40.000	.000	.000	180.000	.000	.000	4.322	242.52	5.95E-06
29	40.000	45.000	.000	5.000	45.000	.000	.000	180.000	.000	.000	2.197	256.43	2.86E-06
30	45.000	50.000	.000	5.000	50.000	.000	.000	180.000	.000	.000	1.146	267.09	1.45E-06
31	50.000	70.000	.000	20.000	70.000	.000	.000	180.000	.000	.000	.416	253.92	3.81E-07
32	70.000	100.000	.000	30.000	100.000	.000	.000	180.000	.000	.000	.028	217.85	1.68E-08

CUMULATIVE ABSORBER AMOUNTS FOR THE PATH FROM H1 TO Z

J	Z (KM)	TBAR (K)	H2O (SCALED LOWTRAN UNITS)	CO2+	O3	HNO3 (ATM CM)	O3 UV (ATM CM)	CNTMSLF1 (MOL CM-2)	CNTMSLF2 (MOL CM-2)	CNTMFRN (MOL CM-2)
1	70.000	217.85	7.454E-12	1.543E-07	2.560E-07	.000E+00	1.583E-05	3.036E+05	3.036E+05	1.085E+11
2	50.000	253.92	5.794E-09	1.702E-05	4.399E-05	.000E+0.	9.672E-04	1.481E+09	1.481E+09	1.009E+14
3	45.000	267.09	2.907E-08	5.172E-05	1.853E-04	.000E+00	3.064E-03	1.159E+10	9.600E+09	5.358E+14

TABLE C-5 (Cont).

4	40.000	256.43	1.263E-07	1.650E-04	8.007E-04	7.727E-37	1.012E-02	6.443E+10	6.244E+10	2.517E+15
5	35.000	242.52	5.436E-07	5.659E-04	2.826E-03	1.055E-08	2.772E-02	3.377E+11	3.357E+11	1.191E+16
6	30.000	230.82	2.482E-06	2.072E-03	8.238E-03	5.493E-06	6.284E-02	1.885E+12	1.883E+12	6.006E+16
7	25.000	223.73	1.003E-05	7.878E-03	2.108E-02	4.040E-05	1.244E-01	7.829E+12	7.827E+12	2.651E+17
8	24.000	221.09	1.275E-05	1.032E-02	2.511E-02	5.663E-05	1.407E-01	9.649E+12	9.647E+12	3.422E+17
9	23.000	220.09	1.566E-05	1.353E-02	2.964E-02	7.064E-05	1.580E-01	1.122E+13	1.122E+13	4.262E+17
10	22.000	219.09	1.875E-05	1.776E-02	3.466E-02	1.002E-04	1.760E-01	1.256E+13	1.256E+13	5.171E+17
11	21.000	218.09	2.202E-05	2.335E-02	4.001E-02	1.215E-04	1.939E-01	1.369E+13	1.369E+13	6.150E+17
12	20.000	217.14	2.548E-05	3.074E-02	4.563E-02	1.427E-04	2.117E-01	1.465E+13	1.464E+13	7.207E+17
13	19.000	216.70	2.931E-05	4.049E-02	5.138E-02	1.622E-04	2.287E-01	1.552E+13	1.552E+13	8.394E+17
14	18.000	216.70	3.372E-05	5.331E-02	5.700E-02	1.8.4E-04	2.443E-01	1.639E+13	1.639E+13	9.783E+17
15	17.000	216.70	3.925E-05	7.018E-02	6.235E-02	2.022E-04	2.583E-01	1.743E+13	1.742E+13	1.155E+18
16	16.000	216.70	4.676E-05	9.237E-02	6.728E-02	2.254E-04	2.705E-01	1.886E+13	1.886E+13	1.399E+18
17	15.000	216.70	5.693E-05	1.216E-01	7.183E-02	2.512E-04	2.810E-01	2.005E+13	2.005E+13	1.735E+18
18	14.000	216.70	7.067E-05	1.600E-01	7.614E-02	2.789E-04	2.903E-01	2.359E+13	2.359E+13	2.196E+18
19	13.000	216.70	9.646E-05	2.106E-01	8.027E-02	3.074E-04	2.987E-01	3.100E+13	3.100E+13	3.076E+18
20	12.000	216.70	1.586E-04	2.772E-01	8.430E-02	3.363E-04	3.064E-01	6.376E+13	6.376E+13	5.229E+18
21	11.000	216.75	3.123E-04	3.649E-01	8.807E-02	3.621E-04	3.132E-01	2.154E+14	2.154E+14	1.064E+19
22	10.000	220.10	6.989E-04	4.776E-01	9.105E-02	3.787E-04	3.183E-01	9.514E+14	9.514E+14	2.432E+19
23	9.000	226.55	1.748E-03	6.191E-01	9.343E-02	3.858E-04	3.221E-01	5.255E+15	5.255E+15	6.145E+19
24	8.000	233.00	4.311E-03	7.955E-01	9.532E-02	3.876E-04	3.249E-01	3.413E+16	3.413E+16	1.697E+20
25	7.000	239.50	1.196E-02	1.014E+00	9.696E-02	3.876E-04	3.273E-01	1.537E+17	1.537E+17	4.222E+20
26	6.000	246.00	2.625E-02	1.284E+00	9.856E-02	3.876E-04	3.295E-01	5.349E+17	5.349E+17	9.263E+20
27	5.000	252.50	5.402E-02	1.614E+00	1.002E-01	3.876E-04	3.316E-01	1.681E+18	1.681E+18	1.905E+21
28	4.000	258.99	1.067E-01	2.017E+00	1.019E-01	3.876E-04	3.337E-01	5.012E+18	5.012E+18	3.761E+21
29	3.000	265.49	2.048E-01	2.505E+00	1.038E-01	3.876E-04	3.360E-01	1.430E+19	1.288E+19	7.206E+21
30	2.000	271.99	3.811E-01	3.096E+00	1.060E-01	3.876E-04	3.384E-01	3.873E+19	2.918E+19	1.339E+22
31	1.000	278.49	6.778E-01	3.806E+00	1.083E-01	3.876E-04	3.409E-01	9.489E+19	5.649E+19	2.378E+22
32	.000	284.99	1.144E+00	4.657E+00	1.107E-01	3.876E-04	3.434E-01	2.067E+20	9.131E+19	4.007E+22

J	Z (KM)	N2 CONT	MOL SCAT	AER 1	AER 2	AER 3	AER 4	CIRRUS
1	70.000	9.534E-09	3.910E-04	.000E+00	.000E+00	.000E+00	9.272E-07	.000E+00
2	50.000	1.996E-06	6.294E-03	.000E+00	.000E+00	.000E+00	1.600E-05	.000E+00
3	45.000	7.117E-06	1.189E-02	.000E+00	.000E+00	.000E+00	3.076E-05	.000E+00
4	40.000	2.688E-05	2.296E-02	.000E+00	.000E+00	.000E+00	5.963E-05	.000E+00
5	35.000	1.104E-04	4.599E-02	.000E+00	.000E+00	.000E+00	1.181E-04	.000E+00
6	30.000	4.886E-04	9.551E-02	.000E+00	.000E+00	8.300E-05	1.591E-04	.000E+00
7	25.000	2.253E-03	2.033E-01	.000E+00	.000E+00	4.392E-04	1.591E-04	.000E+00
8	24.000	3.067E-03	2.369E-01	.000E+00	.000E+00	6.014E-04	1.591E-04	.000E+00
9	23.000	4.181E-03	2.762E-01	.000E+00	.000E+00	8.469E-04	1.591E-04	.000E+00
10	22.000	5.710E-03	3.224E-01	.000E+00	.000E+00	1.204E-03	1.591E-04	.000E+00
11	21.000	7.809E-03	3.765E-01	.000E+00	.000E+00	1.663E-03	1.591E-04	.000E+00
12	20.000	1.070E-02	4.400E-01	.000E+00	.000E+00	2.208E-03	1.591E-04	.000E+00
13	19.000	1.465E-02	5.145E-01	.000E+00	.000E+00	2.793E-03	1.591E-04	.000E+00
14	18.000	2.007E-02	6.016E-01	.000E+00	.000E+00	3.343E-03	1.591E-04	.000E+00
15	17.000	2.748E-02	7.035E-01	.000E+00	.000E+00	3.816E-03	1.591E-04	.000E+00
16	16.000	3.763E-02	8.227E-01	.000E+00	.000E+00	4.219E-03	1.591E-04	.000E+00

17	15.000	5.150E-02	9.621E-01	.000E+00	.000E+00	4.608E-03	1.591E-04	.000E+00
18	14.000	7.851E-02	1.125E+00	.000E+00	.000E+00	5.026E-03	1.591E-04	.000E+00
19	13.000	9.652E-02	1.316E+00	.000E+00	.000E+00	5.504E-03	1.591E-04	.000E+00
20	12.000	[illegible]1E-01	1.539E+00	.000E+00	.000E+00	6.081E-03	1.591E-04	.000E+00
21	11.000	1.809E-01	1.801E+00	.000E+00	.000E+00	6.798E-03	1.591E-04	.000E+00
22	10.000	2.459E-01	2.101E+00	.000E+00	.000E+00	7.758E-03	1.591E-04	.000E+00
23	9.000	3.304E-01	2.442E+00	.000E+00	9.100E-04	8.328E-03	1.591E-04	.000E+00
24	8.000	4.393E-01	2.825E+00	.000E+00	3.426E-03	8.328E-03	1.591E-04	.000E+00
25	7.000	5.788E-01	3.257E+00	.000E+00	8.080E-03	8.328E-03	1.591E-04	.000E+00
26	6.000	7.563E-01	3.740E+00	.000E+00	1.502E-02	8.328E-03	1.591E-04	.000E+00
27	5.000	9.807E-01	4.280E+00	.000E+00	2.351E-02	8.328E-03	1.591E-04	.000E+00
28	4.000	1.263E+00	4.881E+00	.000E+00	3.689E-02	8.328E-03	1.591E-04	.000E+00
29	3.000	1.615E+00	5.549E+00	.000E+00	6.261E-02	8.328E-03	1.591E-04	.000E+00
30	2.000	2.053E+00	6.290E+00	3.105E-02	7.991E-02	8.328E-03	1.591E-04	.000E+00
31	1.000	2.595E+00	7.108E+00	3.122E-01	7.991E-02	8.328E-03	1.591E-04	.000E+00
32	.000	3.262E+00	8.012E+00	1.082E+00	7.991E-02	8.328E-03	1.591E-04	.000E+00

SUMMARY OF THE GEOMETRY CALCULATION

H1	=	100.000 KM
H2	=	.000 KM
ANGLE	=	180.000 DEG
RANGE	=	100.000 KM
BETA	=	.000 DEG
PHI	=	.000 DEG
HMIN	=	.000 KM
BENDING	=	.000 DEG
LEN	=	0

EQUIVALENT SEA LEVEL TOTAL ABSORBER AMOUNTS

H2O	CO2+	O3	HNO3	O3 UV	CNTMSLF1	CNTMSLF2	CNTMFRN
(SCALED LOWTRAN UNITS)			(ATM CM)	(ATM CM)	(MOL CM-2)	(MOL CM-2)	(MOL CM-2)
1.144E+00	4.657E+00	1.107E-01	3.876E-04	3.434E-01	2.087E+20	9.131E+19	4.007E+22
N2 CONT	MOL SCAT	AER 1	AER 2	AER 3	AER 4	CIRRUS	MEAN RH (PRCNT)
3.262E+00	8.012E+00	1.082E+00	7.991E-02	8.328E-03	1.591E-04	.000E+00	48.25

SINGLE SCATTERING POINT TO SOURCE PATHS

SCTTR POINT	SCTTR ALT	SUBTENDED ANGLE	SOLAR ZENITH	PATH ZENITH	RELATIVE AZIMUTH	SCTTR ANGLE	MOLECULAR PHASE F
1	100.00	.00	60.00	180.00	I	120.00	.748E-01
2	70.00	.00	60.00	180.00	I	120.00	.748E-01
3	50.00	.00	60.00	180.00	I	120.00	.748E-01
4	45.00	.00	60.00	180.00	I	120.00	.748E-01
5	40.00	.00	60.00	180.00	I	120.00	.748E-01

TABLE C-5 (Cont).

6	35.00	.00	60.00	180.00	I	120.00	.748E-01
7	30.00	.00	60.00	180.00	I	120.00	.748E-01
8	25.00	.00	60.00	180.00	I	120.00	.748E-01
9	24.00	.00	60.00	180.00	I	120.00	.748E-01
10	23.00	.00	60.00	180.00	I	120.00	.748E-01
11	22.00	.00	60.00	180.00	I	120.00	.748E-01
12	21.00	.00	60.00	180.00	I	120.00	.748E-01
13	20.00	.00	60.00	180.00	I	120.00	.748E-01
14	19.00	.00	60.00	180.00	I	120.00	.748E-01
15	18.00	.00	60.00	180.00	I	120.00	.748E-01
16	17.00	.00	60.00	180.00	I	120.00	.748E-01
17	16.00	.00	60.00	180.00	I	120.00	.748E-01
18	15.00	.00	60.00	180.00	I	120.00	.748E-01
19	14.00	.00	60.00	180.00	I	120.00	.748E-01
20	13.00	.00	60.00	180.00	I	120.00	.748E-01
21	12.00	.00	60.00	180.00	I	120.00	.748E-01
22	11.00	.00	60.00	180.00	I	120.00	.748E-01
23	10.00	.00	60.00	180.00	I	120.00	.748E-01
24	9.00	.00	60.00	180.00	I	120.00	.748E-01
25	8.00	.00	60.00	180.00	I	120.00	.748E-01
26	7.00	.00	60.00	180.00	I	120.00	.748E-01
27	6.00	.00	60.00	180.00	I	120.00	.748E-01
28	5.00	.00	60.00	180.00	I	120.00	.748E-01
29	4.00	.00	60.00	180.00	I	120.00	.748E-01
30	3.00	.00	60.00	180.00	I	120.00	.748E-01
31	2.00	.00	60.00	180.00	I	120.00	.748E-01
32	1.00	.00	60.00	180.00	I	120.00	.748E-01
33	.00	.00	60.00	180.00	I	120.00	.748E-01

TABLE C-5 (Cont).

RADIANCE(WATTS/CM2-STER-XXX)

FREQ	WAVLEN	ATMOS RADIANCE		PATH SCATTERED RADIANCE			GROUND REFLECTED RADIANCE			TOTAL RADIANCE		INTEGRAL	TOTAL
				TOTAL		S SCAT	TOTAL		DIRECT				
(CM-1)	(MICRN)	(CM-1)	(MICRN)	(CM-1)	(MICRN)	(CM-1)	(CM-1)	(MICRN)	(CM-1)	(CM-1)	(MICRN)	(CM-1)	TRANS
18100.	.552	1.35E-39	4.41E-35	2.05E-07	6.72E-03	4.70E-08	1.37E-07	4.49E-03	8.81E-08	3.42E-07	1.12E-02	1.71E-06	.2820
18110.	.552	1.28E-39	4.21E-35	2.05E-07	6.73E-03	4.70E-08	1.37E-07	4.49E-03	8.79E-08	3.42E-07	1.12E-02	5.13E-06	.2810
18120.	.552	1.22E-39	4.02E-35	2.05E-07	6.73E-03	4.71E-08	1.37E-07	4.49E-03	8.78E-08	3.42E-07	1.12E-02	8.55E-06	.2916
18130.	.552	1.17E-39	3.82E-35	2.05E-07	6.74E-03	4.71E-08	1.36E-07	4.48E-03	8.77E-08	3.41E-07	1.12E-02	1.20E-05	.2813
18140.	.551	1.11E-39	3.66E-35	2.05E-07	6.75E-03	4.71E-08	1.36E-07	4.48E-03	8.75E-08	3.41E-07	1.12E-02	1.54E-05	.2811
18150.	.551	1.06E-39	3.49E-35	2.05E-07	6.75E-03	4.71E-08	1.36E-07	4.48E-03	8.74E-08	3.41E-07	1.12E-02	1.88E-05	.2809
18160.	.551	1.01E-39	3.33E-35	2.05E-07	6.76E-03	4.71E-08	1.36E-07	4.48E-03	8.73E-08	3.41E-07	1.12E-02	2.22E-05	.2807
18170.	.550	9.62E-40	3.18E-35	2.05E-07	6.76E-03	4.71E-08	1.36E-07	4.48E-03	8.72E-08	3.41E-07	1.12E-02	2.56E-05	.2805
18180.	.550	9.17E-40	3.03E-35	2.25E-07	6.77E-03	4.71E-08	1.35E-07	4.48E-03	8.70E-08	3.40E-07	1.12E-02	2.90E-05	.2803
18190.	.550	8.74E-40	2.89E-35	2.05E-07	6.79E-03	4.72E-08	1.35E-07	4.48E-03	8.70E-08	3.40E-07	1.13E-02	3.24E-05	.2800
18200.	.549	8.33E-40	2.76E-35	2.03E-07	6.80E-03	4.73E-08	1.35E-07	4.48E-03	8.69E-08	3.40E-07	1.13E-02	3.58E-05	.2797
18210.	.549	7.94E-40	2.63E-35	2.05E-07	6.81E-03	4.73E-08	1.35E-07	4.48E-03	8.68E-08	3.40E-07	1.13E-02	3.92E-05	.2733
18220.	.549	7.57E-40	2.51E-35	2.06E-07	6.82E-03	4.74E-08	1.35E-07	4.48E-03	8.67E-08	3.40E-07	1.13E-02	4.26E-05	.2790
18230.	.549	7.21E-40	2.40E-35	2.06E-07	6.83E-03	4.74E-08	1.35E-07	4.48E-03	8.66E-08	3.40E-07	1.13E-02	4.60E-05	.2787
18240.	.548	6.87E-40	2.29E-35	2.06E-07	6.85E-03	4.74E-08	1.35E-07	4.48E-03	8.65E-08	3.40E-07	1.13E-02	4.94E-05	.2784
18250.	.548	6.55E-40	2.19E-35	2.06E-07	6.86E-03	4.75E-08	1.34E-07	4.48E-03	8.64E-08	3.40E-07	1.13E-02	5.28E-05	.2780
18260.	.548	6.25E-40	2.08E-35	2.06E-07	6.87E-03	4.75E-08	1.34E-07	4.48E-03	8.63E-08	3.40E-07	1.13E-02	5.45E-05	.2777

INTEGRATED ABSORPTION FROM18100 TO18260 CM-1 = 115.19 CM-1
AVERAGE TRANSMITTANCE = .2801

INTEGRATED RADIANCE = 5.453E-05 WATTS CM-2 STER-1
MINIMUM RADIANCE = 3.403E-07 WATTS CM-2 STER-1 (CM-1)-1 AT 18190.0 CM-1

MAXIMUM RADIANCE = 3.421E-07 WATTS CM-2 STER-1 (CM-1)-1 AT 18100.0 CM-1
BOUNDARY TEMPERATURE = 288.20 K
BOUNDARY EMISSIVITY = .600

CARD 5 ***** 0

16.40.21.UCLP, AA, LP2 , 1.024KLNS.

END

12-86

DTIC